

WHY USE AGENT-BASED MODELS TO EXPLORE SOCIAL ISSUES?
THE CASE OF INTIMATE PARTNER VIOLENCE AND SOCIAL SUPPORT SYSTEMS

BY

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THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Urban Planning in Urban Planning
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2010

Urbana, Illinois

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ABSTRACT

Intimate partner violence is a major social problem, and while both men and women can be victims of abuse, the percentage of affected women, especially from low-income, immigrant and African-American communities appears to be higher due to structural inequalities. Women from various socio-cultural and economic backgrounds also differ in ways of seeking help, utilizing services and disclosing abuse to family members, friends and formal sources of help.

Building on socio-cultural and economic representations of intimate partner violence, this thesis presents a spatially explicit agent-based model for simulating help-seeking behavior of battered women within informal and formal social support systems represented by friends, shelters and community service centers.

Results from the model demonstrate the discrepancy between officially reported violence incidents and those experienced in reality. The results also demonstrate the difference in how successful women with different income levels and those from African American, Hispanic and White groups are in becoming economically independent and leaving violent relationship. Overall, the results demonstrate that the formal support systems need to be geared toward low-income women to ensure their independence from abusive relationships.

ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Elizabeth L. Sweet, for her constant support and encouragement; Betsy's enthusiasm allowed me to bridge two disciplines – social sciences and computer modeling – and this work wouldn't have been possible without both her emotional and intellectual support. I would also like to thank my committee members, Dr. Charles R. Ehlschlaeger and Dr. Brian Deal for their valuable insights and comments. Chuck's endless patience in answering never-ending questions about programming and statistical analysis, allowed me to finish the project. Brian's perspective prevented the project, more than once, from becoming overly and unnecessarily complex.

I also wish to thank Lu Rocha from the Women for Economic Justice for sharing her knowledge on violence dynamics in different cultural groups, and Paul Kerschen from the University of Berkeley for providing computer scripts to help process the enormous quantities of raw data.

Immense gratitude goes out to the LEAM Lab at the University of Illinois; without the lab's financial support, this project would have been impossible.

Finally, I wish to thank my family and close friends who have supported me along the long educational road leading up to the program; without that support I wouldn't be here in the first place.

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Introduction

Intimate partner violence (IPV) remains a serious social problem. IPV refers to the physical, psychological, emotional and sexual abuse among intimate heterosexual partners¹ (after Hattery 2009). Both men and women can be victims of family abuse however the percentage of affected women is higher (Catalano 2007; Hattery 2009; Renninson 2003). The National Violence Against Women Survey revealed that 22.1 percent of surveyed women and 7.4 percent of surveyed men have been physically assaulted by an intimate partner in their lifetime (Tjaden and Thoennes 2000). Women appear to use violence primarily in self-defense and are more vulnerable to physical injuries (Hattery 2009; Tjaden and Thoennes 2000). Tjaden and Thoennes (2000) report that women are twice as likely as men to be injured during an assault (compare 31.5% female vs. 16.1% male rape victims). IPV affects people of all races, income levels and social classes but African-American, immigrant and low-income women appear to be at a higher risk (Cunradi et al. 2002; Firestone et al. 2003; Garcia et al. 2005; Hattery 2009; Kim-Goh and Baello 2008; Raj and Silverman 2002; Raj and Silverman 2003; Rasche 1988).

Due to such problems as ineffective data collection system, underreporting of incidents, and the use of different definitions of IPV by criminal justice, social service and health care agencies (Hiselman 1999), there are ongoing debates about IPV rates. According to the U.S. Bureau of Justice Statistics, the average annual rate of non-fatal victimizations of females by intimate partner is 4.2 per 1,000 persons of age 12 or over (Catalano 2007). Other estimates of annual IPV rates vary from 9.3 to 220 per 1,000 women, with the most commonly cited figure of 116 any violent acts or 34 severe violent acts per 1,000 women on the basis of the National

¹ While intimate partner violence exists among homosexual couples as well, this research only discusses violence among heterosexual partners.

Family Violence Surveys (Crowell and Burgess 1996). In a sample of 478 heterosexual women, the Chicago Women's Health Risk Study (CWHRS) revealed that the number of incidents ranged from 1 to 172, with the mean number of 10, which translates into an annual mean rate of 21 incidents per 1000 women (Sabina and Tindale 2008). In a sample of women living in New Mexico shelters, 63.1% reported daily and/or weekly violent episodes (either verbal, emotional or physical), with an overall frequency of abuse ranging from daily to annually (Hilbert et al. 1997: 397). Furthermore, incidents of intimate partner violence rarely get reported to the authorities. Thus, the share of incidents reported to police has been estimated to vary from 2% to 52% (Wolf et al. 2003) of the actual occurring incidents.

IPV has been studied at the individual, institutional and social level (Crowell and Burgess 1996). Such factors as evolution, biology, neurology, personality, gender schemas, male power, social learning, economics, cultural beliefs and structural inequalities have been proposed as influential (Harway and O'Neil 1999; Loue 2001). A recurrent theme is the link between IPV and economic dependence of women in the family (Basu and Famoye 2004; Farmer and Tiefenthaler 1997; Sanders and Schnabel 2006). From this perspective, the greater economic, social or organizational resources there are the lesser at risk of violence should be. As women gain more power they can either dictate their demands or leave the relationship. Formal (police, shelters and social services) and informal (family and friends) support systems are additional resources to increase women's independence and power. While experts from many subject areas identify the positive correlation between intimate partner violence and formal support system, urban planning has been particularly slow in addressing the issue and incorporating gendered perspective into physical and especially social planning (Sweet and Escalante 2010).

In this thesis I first present a review of the literature relevant to IPV and economic and cultural differences in responding to IPV. I then present a spatially explicit agent-based model (ABM) built in NetLogo 4.1 for simulating domestic violence and access to services in Chicago. I combine social-cultural representations of IPV with economic representations of IPV and use a combination of agent-based modeling and GIS approaches to simulate help-seeking behavior of battered women within an informal network of friends and within a formal support system made of shelters and community centers. This model can assist policy-makers in understanding the dynamics of the context in which IPV occurs. It has a potential to be used as a tool for testing policies related to the quality or quantity of support systems as well as their location and evaluating their impact on women from different socio-economic and cultural groups. To the best of my knowledge, this is the first project that attempts to represent the dynamics of intimate partner violence within a spatially explicit social support system and the first project that applies a combination of GIS and agent-based modeling methods.

The thesis is divided into six chapters. In Chapter 1, I put the research on IPV in a historical context and discuss the change in theories and perspectives on IPV from the 1960s onward. In Chapter 2, I introduce a conceptual model and discuss its development on the basis of a literature review on socio-cultural and economic representations of IPV. In Chapter 3, I present a literature review on agent-based modeling and its advantages and disadvantages and discuss the relevance of this method to studying IPV. In Chapter 4, I describe the methodology employed to collect and generate data for the model as well as the implementation of the conceptual model in NetLogo. Finally, in Chapter 5, I present the results of the simulations and conclude with the future research recommendations in Chapter 6.

Chapter 1: IPV in a Historical Context

Over time, the issue of domestic violence has become more visible and less private, as demonstrated by a growing number of academic publications. The theoretical foundations shifted from psychopathological to sociological models and from a victim to survivor point of view, with a particular emphasis on individual experiences, help-seeking behavior and needs of women within a context of their race, ethnicity and immigration status.

1.1 The Sixties

In his review of the literature on intimate partner violence in the 1960s, Gelles (1980) mentions that the violence was thought of as an issue belonging to poor and mentally ill people. Consequently, the research was published in medical journals. The primary interest was in violence against children, while the violence against women rarely if at all attracted any attention. Gelles (1980) further notes that statistics on the subject matter were not collected systematically and overall, the societal attitude held that the violence in families is rare. As per Schults (1960) and Snell et al. (1964), both cited by Gelles, explanations for abuse were based on a psychopathological model and both the abuser and the abused were portrayed as people having personality disorders.

1.2 The Seventies

Due to emergence of such factors as sensitivity of the public to a subject matter of violence in general, growth of the women's movement, the decline of the consensus model of society, and the emergence of a conflict or social action model of society (Straus 1974), the seventies

witnessed an increased interest in the subject of various forms of violence in the home. In addition to the aforesaid, Gelles (1980) suggests a forth factor responsible for this interest, namely an opportunity to carry out the research outside of the clinics and a better accessibility to the methods of analysis.

Research of the seventies became concerned with a definition of abuse and violence and attempted to estimate the extent of male to female violence. Thus, Straus et al. (1980) defined abuse as an act of violence that would be likely to cause an injury to a victim while other definitions also included marital rape and sexual abuse. On a basis of a nationally representative sample of 2,142 individual family members, it was estimated that 16 percent of the surveyed people reported some kind of physical violence in the year of the survey, and 28 percent reported some kind of physical violence in a lifetime. The survey also found that 4.2 percent of married women engaged in violence against their partners, which created much controversy and debate about the interpretation of the findings (Gelles 1980).

Factors explaining the causation of violence at home went beyond mental illness and now included the cycle of violence from childhood to adulthood, socioeconomic status, stress and social isolation, low job satisfaction of the husband, lack of husband's religious affiliation, and alcohol problems (Gelles 1980). In particular, the *culture of violence theory* hypothesized that in large, pluralistic societies some subcultures develop norms of behavior that lead to a greater level of physical violence than in the dominant society (Loue 2001). It has been proposed that degrading images of women in pornography or advertizing are also a form of abuse. Violence against women has been also linked with the portrayal of violence in mass media in general and with the portrayal of rape and sadomasochism in pornography in particular. In addition, mass media may send unclear messages about the use and consequences of violence; e.g., the use of

violence as a necessary means to achieve a goal and a lack of penalties. One of the questions was what is legitimate and illegitimate violence in the context of cultural norms. Thus, one quarter of men and one sixth of women thought that a man could hit his wife under some circumstances (as cited by Gelles 1980: 875).

Ecological theory attempted to link family violence with a broader social context, which included macrosystem (the culture), exosystem (familial formal and informal networks), microsystem (individual couple's ways of communication and resolving conflicts) and ontogeny (family history), as cited by Loue (2001: 23). *Evolutionary theory* hypothesized that the changes in society may trigger intimate partner violence, as during shifts from one economy type to another type (Loue 2001). In general, as societies become more complex, the social relationships become more complex and structured and create a high level of interdependency between individuals in both the society and the family. Obedience to those in power is often reinforced through violence. Other postulates of *evolutionary theory* explain violence and aggression in males as an adaptive mechanism, which is supposed to defend a female mate from other competitors (see Loue 2001 for more details).

General systems theory, proposed by Straus (1973) essentially links positive feedbacks between individual, family, and society levels that reinforce violence, namely family history, war, crime rates, economic dependence of women, beliefs in traditional gender roles and other factors. *Resource theory* posits that the person who brings in more valued resources has more power (money, property, prestige and contacts) but as the person has more control over the resources the less likely he or she will use violence (Goode 1971).

1.3 The Eighties

In the eighties, the research on violence at home expanded to include such issues as violence towards parents and the elderly, sexual abuse and courtship violence (Gelles and Conti 1990). In addition to investigating causation factors related to violence, more interest developed regarding the consequences of abuse to women, such as depression, psychological distress and anxiety. Methodologically, there were still problems with assessing the changing rates of intimate partner violence due to the lack of good national official reports. In the eighties, some previous theories continued to be developed and new ones were proposed.

As summarized by Loue (2001), *exchange theory* essentially hypothesized that if the benefits of the abuse outweigh its costs, the person will continue abuse. Similarly, *investment theory* postulated that the willingness to stay in the relationship increases if the benefits of leaving are lower than the costs of staying. In assessing costs and benefits, an individual may consider intrinsic (the amount of time already invested in the relationship) and extrinsic (shared friends, activities and life events) types of investment. *Social learning theory* attempted to explain intergenerational transmission of violence and considered such factors as individual, couple and societal characteristics, stress, violence and aggressive personality. *Traumatic bonding theory* hypothesized that women stay with an abusive partner as over the course of a violent relationship a dominant partner becomes more dominant and a subjugated partner becomes more dependent emotionally.

According to Kurz (1989), two major sociological theories developed in the eighties were *family violence theory* and *feminist theory*. *Family violence theory* suggests that all family members engage in violence and that intimate partner violence is gender symmetric. As cited by Kurz (1989: 491), it has been estimated that 12.8% of husbands were violent toward their wives,

while 11.7% of wives were violent toward their husbands. Overall, 49% of the couples reported that both partners were violent. In a much later study, Straus (2004) recomputed rates on the basis of National Family Violence Surveys and argued that women committed 124 assaults per 1,000 couples as compared to 122 assaults committed by men as reported by women themselves. Straus (2004) also argued that while the National Violence Against Women Survey reported men's violence rate to be three times more than women's, women were perpetrators of abuse in 39% of the cases.

Kurz (1989) summarizes the assumptions of the *family violence theory* as follows: due to stresses associated with unemployment, financial insecurity or health problems, family members become violent to each other; family members look at the society, which at large accepts violence as means of solving conflicts; and families socialize children into violence by means of physical punishment.

According to the *feminist perspective*, gender symmetric violence does not exist and when women engage in violence they do so in self-defense. Violence is viewed as an instrument of control that men exercise over women. This form of control is further documented historically, as in the early 19th century, some state laws in the United States approved wife beating. Since women are associated with domestic chores, their status is lower than that of men whose primary occupation is in the public sphere. Furthermore, women have fewer economic opportunities to end the violent relationship (e.g., a lack of job training or child care or lower wages). Finally, the social attitude holds that partner violence is a private, invisible issue. Social institutions, such as police, health and social agencies, consequently have a low response rate to IPV cases (Kurz 1989).

1.4 The Nineties

According to Johnson and Ferraro (2000), one of the important themes of the nineties was the distinction between types of violence. Johnson and Ferraro (2000) described the following types and their characteristics:

- common couple violence
 - usually happens during an argument
 - one partner may become physically violent
 - is likely to be mutual
 - not likely to be severe
 - not likely to escalate over time
- intimate terrorism
 - happens in a context of control when one wishes to control one's partner
 - is more likely to escalate over time and include serious injury
 - is less likely to be mutual
 - can include emotional abuse
- violent resistance (self-defense)
 - appears to be done almost entirely by women
- mutual violent control
 - both man and woman in a relationship are controlling

The interpretation of male to female and female to male violence continued to be a challenging issue. However, Johnson and Ferraro (2000) asserted that authors arguing for gender

symmetric violence do not take into account the context in which violence happens and essentially lump all four types of violence together. They suggested that common couple violence appears to be gender symmetric but intimate terrorism is a primarily male and violence resistance is a primarily female pattern. Understanding of the context has been improved by more research on couples of the same sex, courtship couples and dating and cohabiting couples as well as theories on social construction of gender roles and broader social context.

More attention was paid to intimate partner violence, race and ethnicity in a context of structural inequalities (Johnson and Ferraro 2000). The primary distinction was made between White and Black women though later studies included American Indian, Asian and Pacific Islander women (Ucko 1994). For example, Hampton et al. (2003) linked intimate partner violence in African American communities to structural and cultural-community contexts. African American men are often socialized into 'male-dominant' culture yet they often cannot fulfill their roles as a provider due to higher unemployment/underemployment rates and lower earnings. Historically, African American women have been economically independent though their employment rate and earnings are lower than those of White women. Hampton et al. (2003) argued that in this context African American men cannot fulfill their expected social roles and violence becomes one of the ways to express their masculinity. Finally, African American communities tend to be isolated and women may lack access to information and formal support systems outside of the community.

With an emphasis on race and ethnicity, it became important to look not just at the number of incidents but to consider such issues as availability of culturally sensitive services, the public perception and awareness of intimate partner violence in different communities and the

applicability of Western definitions of IPV and ways of coping with IPV to other cultures (Johnson and Ferraro 2000).

Johnson and Ferraro (2000) concluded their review of the literature of the decade with the following themes: women are seen not as victims but as survivors; ending violence is seen as a process that can take years; emphasis is placed on coping with partner violence and on the decisions that women make to end violence; research continues on psychological, behavioral and social (poverty, employment and welfare status and homelessness) consequences of partner violence.

1.5 The Aughts

During the last decade, there has been a growing body of research on response to intimate partner violence by race, ethnicity, immigration, and acculturation status (Abraham 2000; Bui 2003; Bui and Morash 1999; Dutton et al. 2000; Fowler and Hill 2004; Ganatra 2001; Hazen and Soriano 2005; Huang and Gunn 2001; Lee et al. 2002; Lee 2007; Midlarsky et al. 2006; Magen and Wood 2006; Rhee 1997; Shirwadkar 2004; Van Hightower et al. 2000; Yick 2000; Yick and Agbayani-Siewert 1997; Yoshihama 2002). Frias and Angel (2005) argued for a more refined definition of ethnic categories and a finer understanding of what violence means for people from different cultures. The authors found differences in risk profiles for low-income Hispanic subgroups, African Americans and Non-Hispanic Whites. For example, Mexican-origin women reported IPV rates similar to those of African Americans, while Dominican and Puerto Rican women reported lower rates of IPV (Frias and Angel 2005). Aldarondo et al. (2002) distinguished between Puerto Rican, Mexican, Mexican American and Anglo-American women and found that reported abuse was higher among Mexican American and Puerto Rican women

than among Mexican and Anglo-American women. For many women in South Asian community, the concept of a 'marital rape' is an alien one (Dasgupta 2000).

Acculturation plays role in decreasing or increasing the odds of IPV. According to Garcia et al. (2005), as the more acculturated Latinas had become, the greater odds they had of reporting IPV than the least acculturated Latinas. The authors suggest that the traditional Latino culture, which praises family values contributes to fewer reported IPV occurrences. Similar results were obtained by Firestone et al. (1999) who found that the rate of abuse among US-born Mexicans were 50 % higher than among Mexican immigrants and that higher acculturation increased the odds of reported abuse. The authors reached a similar conclusion, suggesting that immigrants practiced Mexican male-dominated and maternity-protective culture more often than those born in the US. In a study done by Firestone et al. (2003), such factors as increased education, income and acculturation were associated with higher risk of reported IPV occurrences and less egalitarian roles among Latina women. Firestone et al. (2003) suggested that risk of abuse is lower if both partners believe in traditional gender roles. However, the risk for abuse among immigrants becomes significantly higher due a combination of such factors as a woman contributing a higher relative share of family income, non-egalitarian decision-making processes, high levels of acculturation stress, and nontraditional gender role attitudes.

Among Korean American families, egalitarian couples and female-dominated households reported fewer IPV occurrences than male-dominated families (Kim and Sung 2000). Thus, the rate of physical assault of females was four times higher in male-dominated marriages than in egalitarian ones. Korean American males also adhered to traditional gender roles more often than women. Grzywacs et al. (2009) investigated women's employment as an agent of acculturation for Mexican immigrant couples. The authors noted that 70.2% of women were engaged in labor

force in the US as opposed to 43.2% of women in labor force in Mexico. Using qualitative analysis of 20 participants, Grzywacs et al. (2009) indicated that once in the U.S., woman's entrance into labor force was often a facilitator of IPV since men feared they would lose their role as a bread-winner and that women would become more empowered and independent.

Sugihara and Warner (2002) found that among US-born Mexicans, Mexican American men have retained aspects of traditional dominance and thus engaged in physical aggression, while Mexican American women departed from traditional gender roles more frequently. Using a sample of immigrant Latinos, Moracco et al. (2005) also found that unlike men, women were significantly more likely to perceive IPV as a more serious problem in the community. In Korean and Vietnamese Americans, women had less pro-violent attitudes than men (Kim-Goh and Baello 2008) and a higher level of acculturation resulted in women seeking help more frequently outside of the community.

Finally, research continues on women's coping strategies, use of services, frequency of use and perceived usefulness of services (e.g., Allen et al. 2004; Griffing et al. 2002; Grossman and Lundy 2007). The research is shifting toward the recognition that service providers actually need to consider women's needs (Cole 2001; Honeycutt et al. 2001; Merchant 2000; Postmus et al. 2009).

1.6 Conclusion

In this chapter, I provided a historical context in which intimate partner violence has been studied and outlined major theories and themes. The theory has shifted from a proposition that intimate partner violence occurs only among mentally ill people to encompass such themes as structural inequalities and socio-economic and cultural differences of the context in which

intimate partner occurs as well as differential responses of women to IPV within such contexts.

In the next chapter I will provide a more detailed review of the literature of the mid 1990s – 2000s in order to lay out a theoretical foundation for my model. In Chapter 2 I will also discuss the conceptual model and its assumptions.

Chapter 2: Development of the Conceptual Model

In Chapter 1, I demonstrated that the issue of intimate partner violence is a very complex problem that must be addressed from multiple perspectives. However, the goal of this study is not to determine which factors are responsible for intimate partner violence, as volumes have been written on this subject. For the same reason, neither is it to indicate who initiates violence. The goal is to understand help-seeking behavior of women as they navigate through a formal and informal support system. Ending a violent relationship is often a cyclical and long process that may take as few as 2 years and as many as 20 years (Hilbert et al. 1997), with a mean of 8 years (as cited by Bell 2003: 1246).

As I indicated in Chapter 1, proponents of different sociological theories generally agree that economic dependence of women in the family as well as fewer opportunities available to women outside of the family, such as a lack of job training or child support, is one of the influential factors putting women at a higher risk of intimate partner violence.

Here, I will demonstrate that while survivors of domestic violence share a majority of structural barriers to economic independence in common, women from different ethnic and social backgrounds have dissimilar help-seeking behavior, which influences the success rate of accessing and using services. The differences may include the desire to disclose abuse, the level of informal support, the desire to contact police or other formal sources of help. Women make decisions whether to seek help on the basis of many factors, such as cultural experiences, immigration status, the availability of information and actual and perceived usefulness of resources. During the help-seeking process, women may experience differential treatment by the

system and the level of support essentially makes an impact on the chance of ending a violent relationship or decreasing a level of violence at home.

The recurrent themes are access to and use of information, legal aid, social services (formal support) and informal support (e.g., Allen et al. 2004; Griffing et al. 2002; Goodman et al. 2005; Kaukinen 2002). I will first elaborate on the economic context and consequences of IPV, namely the linkage between IPV, homelessness and employment (Coulter 2004; Fox et al. 2002; Moe and Bell 2004; Press and Fagan 2005; Riger and Staggs 2004; Tolman and Wang 2005). I will further examine each of the themes of access to and use of information, legal aid, social services and informal support. Finally, I will present the conceptual model itself.

2.1 Economic Context

I have discussed so far that there is a correlation between intimate partner violence and economic status of women. According to the Bureau of Justice Statistics (Catalano 2007), the annual assault rates by income over 2001-2005 per females aged 12 or more were 12.7 for a \$7,500 range, 6.2 for a \$7,500 to \$24,999 range, 5.2 for a \$25,000 to \$49,999 range and 2.0 for a \$50,000 or more range.

While women from higher socio-economic context tend to solve their problems themselves by entering private therapy, hiring a lawyer, renting an apartment or a hotel room (Hattery 2009), those from lower socio-economic strata lack these opportunities as well as access to social services and other resources (Allen et al. 2004; Gillum 2009; Logan et al. 2004; Moe 2007; Wolf et al. 2003). As cited by Landis (2007: 113), 27% of domestic violence survivors have no access to cash, 34% have no access to a checking account, 22% have no access to a car and 51% have no access to a credit account.

Women from marginalized communities make numerous attempts to leave an abusive relationship (Sullivan et al. 1992) but often cannot succeed because of abundant structural barriers. The lack of access to employment, education, transportation, housing, childcare, financial and legal support influence their ability to increase independence, to make the decision to leave and then to be able to succeed post separation (Sullivan et al. 1994). For example, Griffing et al. (2002) report that over 50% of women in their sample cited economic need as a reason for having returned post separation. Websdale and Johnson (2005) estimate that 80-90% of women returned to their abusive relationship within 6 months upon exiting the shelter if they did not participate in a Job Readiness Program. One of the shelter providers reported that nearly 85% of women return to their abusive relationships due to lack of employment and housing (Crenshaw 1997).

Lack of structural support has also been associated with a short-term or long-term homelessness and housing instability (Bassuk et al. 2001; Baker et al. 2003; Menard 2001). Pavao et al. (2007) found that women who experienced IPV in the past year were four times more likely to have an unstable housing situation (defined as being late with paying rent or mortgage, being without their own housing or having to move more than once in a year). In a sample of 45 women living in Chicago shelters, Levin et al. (2004) found that 56% of women had experienced IPV at least once in a lifetime. For 22% of women, domestic violence was a direct reason for homelessness as they had no prior work history and no personal income upon leaving.

Numerous studies have linked IPV and the ability to maintain or find employment. According to Romero et al. (2003), women with prior IPV history reported significantly higher rates of job loss as well as more difficulty finding employment. Thus, women with a prior history

of IPV were more likely to miss work due to problems with their own health than women without such history (51.5% vs. 38%) or lose a job (26.1% vs. 10.3%). Lack of child care was another significant factor (reported by 47.1% of women with IPV history as a barrier to finding a job and by 31.9% as a factor in losing a job). As cited by Bell (2003: 1258), the lack of formal child care is sometimes a factor in women's decisions to stay in a violent relationship as they have to rely on their partner. Overall, women with a history of intimate partner violence experienced 50% to 100% higher barrier rates to maintaining employment than those who did not (Romero et al. 2003).

Browne et al. (1999) found significant differences in the ability of women to maintain full-time employment in the context of intimate partner violence. Thus, Browne et al. (1999) reported that women who experienced IPV were less than half as likely to maintain at least 30 hours of work during 6 months or more compared to women without such an experience. A stronger correlation was found for women working 40 hours/weeks as they had one fifth the chance to continue working full time for 6 months or more as compared for women who had no IPV experience. In relation to public policy, Browne et al. (1999:420) concluded that "the documented negative relationship between partner violence and women's capacity to maintain work over time suggests ... that experiences with partner violence in the prior year seem to have *ongoing* [italics mine] negative effects that interfere with women's capacity to maintain work". As a result, for some women it may not be possible to escape a violent relationship by means of employment.

On the basis of interviews with 17 low-income women, Bell (2003) revealed that intimate partner violence limits women's ability to work, and that the welfare system was not helpful due to the lack of child support and childcare. Bell (2003) reported that for many women low-wage

work was unstable, as they had to work night and weekends, which made it difficult to obtain childcare and transportation. Furthermore, some women could not keep jobs because their partner harassed them at work or because they had to miss too many hours due to a repeated abuse. For some women, high levels of anxiety and depression were barriers in keeping a stable position.

Somewhat similar conclusions have been reached by Meisel et al. (2003) for a sample of two California TANF (Temporarily Assistance for Needy Families) populations. Thus, for working women there was not a significant difference in work hours for those with and without prior IPV experience. However, women with prior IPV experience worked significantly fewer weeks and were more likely to lose a job. Tolman and Rosen (2001) did not find any significant relationships between domestic violence and employment for a sample of women on welfare but they reported that recent domestic violence survivors were significantly more likely to experience such material hardships as being homeless, facing eviction and experiencing food insufficiency.

2.2 Informational Resources

Many women do not know how or where to access services or whether any services exist. According to a Statistic Canada Survey, out of 12,300 randomly selected women, 16% of those in violent relationships did not know whom to contact for help (as cited in Harris et al. 2001). Among a sample of South Asian immigrant women in Greater Boston, 50% were not aware of available services in their area (Raj and Silverman 2003) and 45% of sampled Latina women residing in one of the southeastern states did not know how to get help (Murdaugh et al. 2004). According to Ingram (2007), the level of service awareness was two times less among Latina

women, many of which were immigrants, than among non-Latinas. Not surprisingly, the length of residence was significantly related to low knowledge about available services (Raj and Silverman 2003). Bosch and Schumm (2004) reported that 50% of rural women were not aware of advocate services for women. Lack of information is one of the factors for not contacting police, social services, friends and hospitals (Fugate et al. 2005).

2.3 Social Service (Shelters and Agencies) Resources

Availability and accessibility of services are an important factor in establishing economic independence for low-income women. However, the usage of services is often influenced by women's socioeconomic and cultural background.

An encouraging report by Lyon et al. (2008) informs that 82% of surveyed shelters in eight states, including Illinois, had staff who spoke some language other than English and 72% had staff who spoke Spanish. However, a decline in governmental funding deeply cut many IPV services. According to the Illinois Coalition of Domestic Violence (2008), Illinois received \$11.6 million in fiscal 2008 compared with \$16.2 million in fiscal 2006. Consequently, 27 out of 102 counties have ceased to provide any services in comparison since 2002. As a result, women may have to travel to other counties for help. From 2007 – 2009, there was a 14% decline of children clients and 6% decline of adult clients, as well as a 12% decline in hours dedicated to survivors. According to the National Census of Domestic Violence Services, the ratio of unmet requests to served persons in Illinois was one-to-three in 2008 compared with one-to-nine in 2006, a three fold decrease in service provision in two years. Located in Chicago, Greenhouse Shelter alone is forced to turn away each month more than 600 women and children requesting emergency shelter due to the lack of space. With a space for only eleven people, the Hamdard Center - a

suburban Chicago shelter tailored for the needs of the American Muslim women, turned away 859 women and children in 2008 (Bohn 2009). In 2006, Rainbow House closed its shelter on Chicago's South Side (Landis 2007).

As of 2007, Chicago had 15 non-profit service agencies with crisis call lines for the survivors of domestic violence. Thirty agencies provided a range of legal advocacy services, with eight agencies providing legal services for free. Six domestic violence emergency shelters provided a total of 166 beds. Six agencies offered non-emergency housing programs, with a reported capacity ranging from 4-5 up to approximately 40-50 families. Forty agencies provided counseling services, such as safety planning, information, guidance in decision-making and supportive listening and other services, while 19 agencies provided counseling services for children. These and other details on the availability of domestic violence services in Chicago may be found in a report by Landis (2007).

As I have already discussed, women from diverse ethnic backgrounds have been shown to have different frequencies of use and perceived effectiveness of various help sources (Allen et al. 2004; Brabeck and Guzman 2008) and therefore services should be designed correspondingly (Cole 2001). Thus, Fugate et al. (2005) noted that a lot of research evaluates satisfaction with social services or legal offices but these studies lack examination why women decide to use or not use a specific service or intervention. The authors noted the following major themes for not contacting police, friends, agency or a doctor: not needed/not useful, presence of barriers, in order to protect partner, privacy reasons, possible consequences, and fear. Specifically, police were associated with consequences (12.8%), such as immigration status, fear of losing housing and problems with child protective services. Barriers to help included no money, time or insurance.

Lipsky et al. (2006) found significant differences in service utilization between White, Black and Hispanic women. For example, Non-Hispanic White women were nine times more likely to use emergency department services and twice as likely to use domestic violence services compared with Hispanic women. According to Lipsky et al. (2006), the likelihood of utilizing services for Hispanic women was also associated with a level of acculturation. South Asian women may be reluctant to reveal abuse to domestic violence services as it is considered family matter (Dasgupta 2000). Many immigrant women fear deportation or fear any authorities as a class and consequently do not want to contact any official sources of help. Thus, in a sample of Latino women, 72% were afraid of deportation and 49% did not trust people who provide services (Murdaugh et al. 2004).

Ingram (2007) reported that more Non-immigrant Latinas than immigrants contacted a formal agency (14.7% vs. 6.9%). While Ingram (2007) did not find any significant differences in service utilization between Latinas and Non-Latinas, Non-Latinas contacted shelters more often (14.2%) than Latinas did (10.2%). More Non-Latinas talked to health care workers (11%) and the clergy (12.6%) than Latinas did (7.9% and 9.6%, respectively). According to Landis (2007), 54% of African American domestic violence survivors who called the Chicago Help Line sought shelter services as compared to 26% White and 24% Latino domestic violence survivors in 2005. Thirty-three percent of White and thirty-seven percent of Latina survivors requested legal assistance more than other services.

Though not providing any explanations, George et al. (2010) found significant differences in service utilization between White (n = 404) and Non-White (n = 580) women in Chicago shelters. With an exception of a category named 'other services', Non-White women were significantly less likely to receive civil legal/criminal legal advocacy/order of protection (60.3%

vs. 73.8%), criminal legal advocacy/charges (5.9% vs. 13.1%), other legal help (28.6% vs. 37.4%), transportation services (31.7% vs. 45.4%), medical assistance (15.9% vs. 25.5%), and family counseling services (17.1% vs. 29.2%). There was no significant difference in the percentage of women receiving all other services (e.g., educational, employment and economic assistance and others) but overall, Non-White women on average received significantly fewer hours of total services (40.83 vs. 55.27), fewer service contacts (51.2 vs. 85.0) and fewer services in total (8.05 vs. 8.74).

Hilbert et al. (1997) found a significant correlation between the length of stay in a shelter, severity of abuse and probability of return. In a sample collected in three New Mexico shelters, 35.6% of women returned to their abusers after the shelter time though the authors did not specify the reasons for return. Yet Hilbert et al. (1997) suggested that the longer women stay at the shelter the more likely they are to become independent since the purpose of shelters is to help their residents become independent. Specifically, availability of medical and psychological help and culturally sensitive attitude as well as education of women about dynamics of violence may be one of the factors determining women's success in ending the relationship. While not explicitly mentioned by Hilbert et al. (1997), it is possible that financial need was one of the factors for return (47.2% of women had less than GED, 35.9% had GED or an equivalent education and overall, 66.5% were unemployed and relied on public assistance).

Physical distance may be a factor in some cases, especially in rural areas (Bosch and Schumm 2004) though the lack of access to a personal car and a bad transportation system may be a factor in urban areas. Bosch and Schumm (2004) reported that in a rural area the distance to the closest shelter ranged from a min 20 to a max of 149 miles, with a mean of 77.91 miles. Approximately a third of women who did not have enough access to formal support, reported not

having professional services in the community and not being treated with respect or confidentiality by service providers (Bosch and Schumm 2004).

Some scholars note that the majority of services are designed for White, middle class women (Donnelly et al. 2005). Thus, shelters often tend to be located in primarily White neighborhoods (Donnelly, Cook and Wilson 1999) and it is possible that women of color are not aware that the services exist if they are outside of the community (Donnelly, Cook and Wilson 1999; Hampton et al. 2004). African-American women may not want to use services designed for White women as they may view violence as a result of White oppression of men of color, not as gender oppression operating in their own lives” (Donnelly et al. 2005: 12). As cited by Donnelly et al. (2005: 12-13), a minority community may have norms against using services designed for White women. Furthermore, many privately funded shelters tend to be located in minority communities and serve minority and immigrant women, while publicly funded shelters tend to be located in primarily White neighborhoods. Many private shelters, such as those funded by churches or local organizations, tend to have special rules of admittance.

Donnelly et al. (2005) suggest that when service programs do not recognize cultural and ethnic diversity they may be seen as one-size-fits-all, while on the other hand, if they create culturally specific services the service programs may be seen as racist or separatist. However, a problem with the lack of culturally sensitive services is that if the woman has special needs, such as a special diet or belongs to a different religion, she may feel that the service program is not welcoming her.

Thus, a relatively recent story published in Medill Reports Chicago (Bohn 2009), discussed some of the issues Muslim women face. A battered Pakistani-American woman had difficulty finding a shelter that would accommodate her dietary and religious needs. When she finally

found one in suburban Chicago, she felt like “she is with family” – a feeling that is important for psychological well-being.

2.4 Legal Aid (Police) Resources

The decision to interact with legal authorities is influenced by an intersection of race, social class, immigration status, prior experience with the system and availability of legal help (Akers and Kaukinen 2009; Apsler et al. 2003; Felson, Ackerman and Gallagher 2005; Felson et al. 2002; Fleury 2002; Kaci 1994; Wilson and Jasinski 2004). For example, Arab Americans may be unwilling to contact police, because the police are considered a source of oppression (Abu-Ras 2007). Arab Americans may be especially reluctant to contact any legal sources of help because of the anti-Arab policies put in place after the 9/11 attacks and Mexican immigrant women may be afraid of deportation in the context of anti-immigrant policies and sentiment. A National Survey of the Courts revealed a shortage of interpreters and lack of instructional materials in languages other than English (Uekert et al. 2006), which creates an additional barrier for non-English speaking women.

Yet the response of the system is a result of the same social factors. While many women report satisfactory experiences from police intervention (e.g., Johnson 2007), police have been shown to treat women differentially. Thus, Avakame and Fyfe (2001) found that police were less likely to arrest in domestic violence assaults compared to other assaults. In addition, police were more likely to arrest if a woman was White and/or wealthy and the assailant was Black. Comparing police response to domestic violence cases in a medium-sized Midwestern city, Robinson and Chander (2000) found that Black women received fewer police services than White women. The police were generally more lenient to older suspects and the arrest was more

likely to be made on the behalf of an older White woman. Furthermore, the police were less likely to provide services to a Black woman if they believed that she had a drug or alcohol problem. In addition, for Black women the presence of children in the scene decreased the odds of arrest twofold as well as did their cohabitation status. Very similar results have been obtained by Lichtenstein and Johnson (2009), who analyzed the FBI data on arrests and prosecution across age and race. In addition, Lichtenstein and Johnson (2009) report that the rate of resolved cases was lower for older Black women than for older White women by approximately 15%. According to Senturia et al. (2000), police often demonstrate prejudice, which for Native American women would translate into a label of a “drunken Indian” and her story would not be taken seriously. Prejudice for African Americans would mean that if a White man was a perpetrator his story will be more likely to be believed. As reported by Dasgupta (2000:181), “a family court judge vacated a South Asian woman’s temporary restraining order by commenting that the abusive behavior of her spouse may be “cultural”.

In rural Illinois, police have been reported to ignore the survivor’s request to arrest, not giving referrals to other help sources or not responding to a call promptly (Benson 2009). Thus, some survivors reported that it was necessary to make several calls to the authorities in order to receive a referral to a local crisis center. Finally, some police officers were not aware of Illinois domestic violence laws and wrongly asserted some women that there is nothing they can do if stalking occurs in an official marriage (Benson 2009).

A problem specific to rural areas (less so in urbanized areas) is that people in small communities tend to know each other well. As a result, a woman may not want to contact police because the officer may be close friends with her partner. Similar to Illinois, women in the rural

Deep South hesitated to contact the police due to the lack of confidentiality and mistrust of the authorities (Lichtenstein and Johnson 2009).

Police have been also reported to be insensitive to the needs of survivors. Stephens and Sinden (2000) reported such attitudes as minimizing the situation, disbelieving women, having ‘we don’t care’ and ‘macho cop’ attitude. In Seattle, women of different racial, ethnic and immigration status groups reported that sometimes police would arrest both the victim and the perpetrator without distinguishing between the two (Senturia et al. 2000) and would refuse to help if there was no evidence of psychological abuse. Sometimes, police would not respond to a call if the previous calls did not involve physical violence. According to Lichtenstein and Johnson (2009), police officers in the Deep South admitted that the abused individual would be arrested together with an abuser in at least 50% of the cases.

2.5 Informal (Family and Friends) Resources

Friends and family are often the first source of help as they may provide emotional, informational and tangible support. Informal support also makes a positive impact on psychological well-being of women in violent relationships (e.g., Carlson et al. 2002; Glass et al. 2007). Women from different cultural backgrounds differ in their desire to disclose abuse to family members or friends (Hadeed and El-Bassel 2006). Consequently, family members and friends differ in their level of support or the level of recognition of the problem (Carlson and Worden 2005; Chabot et al. 2009; Worden and Carlson 2005). Yoshioka et al. (2003) reported that in their sample South Asian women were more likely to disclose abuse to family members or a friend but less likely to make it known to police or a counselor; South Asian women also received a lower level of support from non-kin members (average item 2.9) compared with

Hispanics (3.2) and African Americans (3.5). Griffith et al. (2006) found that Trinidadians were more tolerant of IPV than Americans and were less likely to provide support to friends, neighbors or coworkers in IPV cases. According to Ingram (2007), more Latinas disclosed abuse to a family member than none-Latinas (31.5% vs. 25.4%).

Women holding stronger patriarchal beliefs were less likely to recognize spousal abuse by Western definitions (Ahmad et al. 2004) and thus were less likely to help other battered women through formal organizations and are less likely to seek help themselves. Abu-Ras (2007) came to the similar conclusion for Arab women. Finally, Raj and Silverman (2003) reported that 10% of South Asian immigrant women would have no social support if they were abused. Furthermore, social isolation was associated with an increased likelihood of violence, as women with no social support in the United States were 3 times more likely to have been physically assaulted.

2.6 Conceptual Model

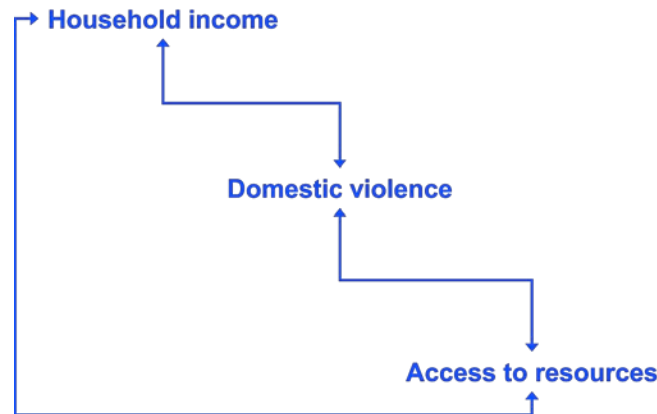
The issues I discussed so far laid out a foundation for the conceptual model of women's help-seeking behavior in a system of a formal and informal support. As women from different ethnic and social backgrounds have dissimilar help-seeking behavior, the success rate of accessing and using services and hence achieving independence will be different as well. Here, I present the conceptual model at three stages of development: a very basic model with linear relationships between domestic violence and social services, an expanded model showing how women cycle between violent homes and systems of support and finally, an individual-based model illustrating the decision rules for each woman as she cycles through the system.

The model is based on the following assumptions:

- violence can happen between two intimate heterosexual partners
- when violence happens, women are more likely to suffer physically
- women have fewer opportunities than men to end violence by means of becoming economically independent
- access to and availability of resources, defined as social services (agencies and shelters) and informal services (friends' support), are a defining factor in becoming economically independent (**Figure 1**)
- personal income has a negative effect of the chance of violence at home
- socio-economic and cultural context has an effect on women's help-seeking behavior and on response of the service system.

Figure 1 illustrates straight-forward linear relationships between resources, violence and income. Thus, higher household income in general (or personal woman's income) lowers the chance of domestic violence but higher rate of domestic violence lowers the income. Better access to resources increases income and higher income increases access to resources. Better access to resources decreases violence but greater violence intensifies the use of resources.

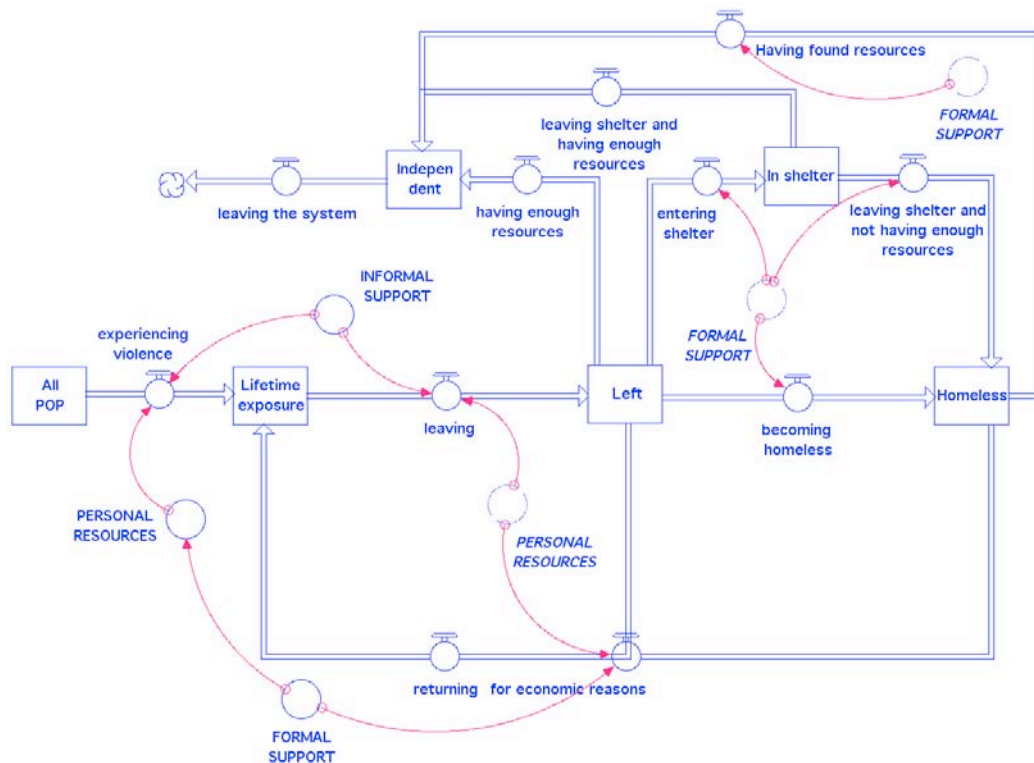
Figure 1. Basic Conceptual Model.



I must note that **Figure 1** represents a simplified reality of one of the many possible universes that some battered women live in. Furthermore, the use of resources as defined here is also just one of the many possible strategies that women employ. Thus, ending violence by means of leaving the relationship or the community is not a viable solution for many women, especially for cultural reasons (Dasgupta 2000). It is also possible that for some women an increase in personal income may result in increase of violence at home (Grzywacs et al. 2009). While it is necessary to keep this limitation in mind, this level of simplification is adequate for the purpose of the model – that is mathematically predicting the effect of formal and informal support on IPV rates.

Figure 2 illustrates an expanded conceptual model, which shows how women cycle between violent homes and the defining points in the system.

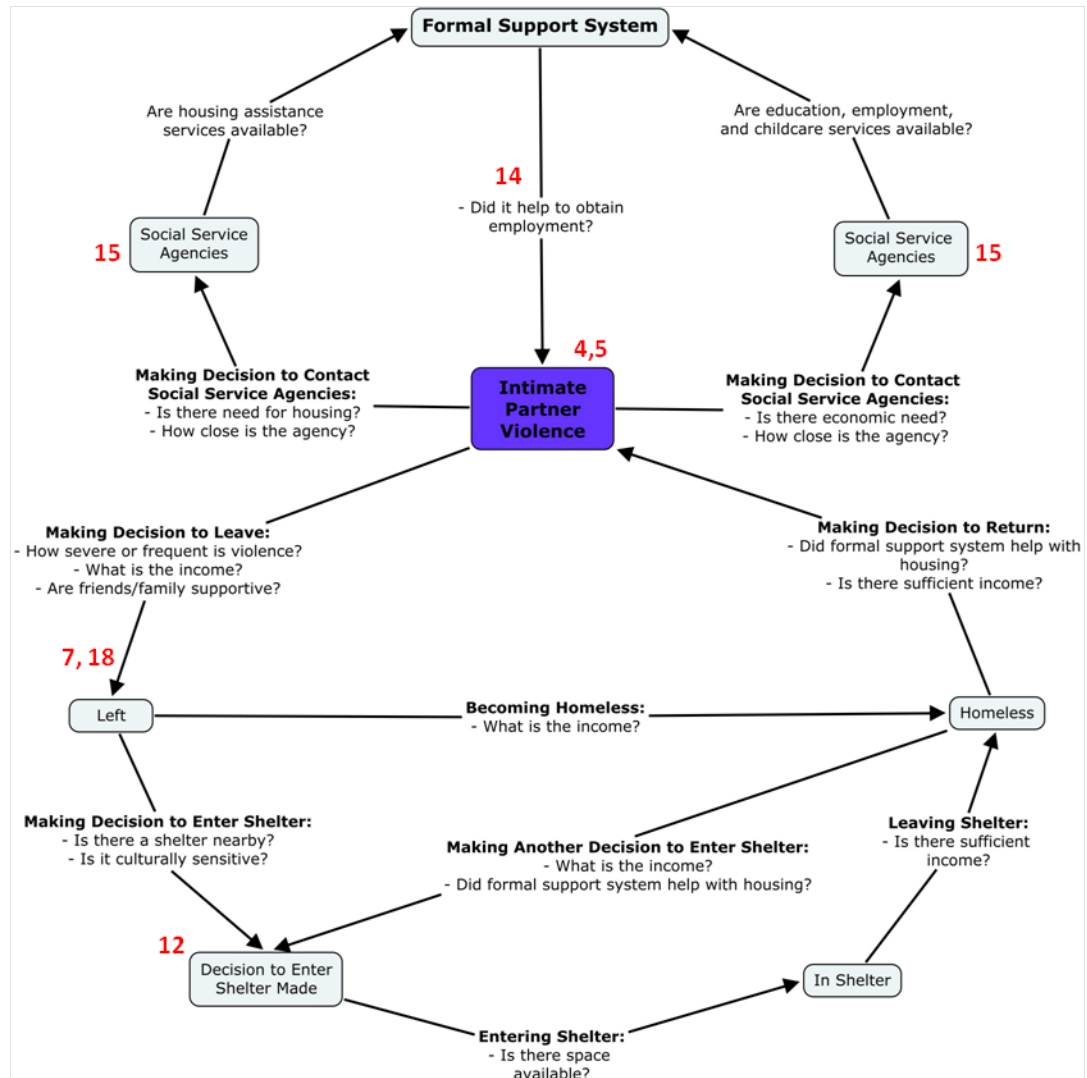
Figure 2. Expanded Conceptual Model.



In the beginning of the system certain population exists and some percentage of the population may experience violence. The rate of domestic violence is determined by personal resources (i.e., income) and formal support system (i.e. resources aimed at helping women finding employment). Some percentage of battered women may leave and they enter a shelter, become homeless (which is essentially equal to not having sufficient resources), then they become independent or return back to the relationship for economic reasons. After their time in a shelter is over, some women may become homeless and others have enough resources to be economically independent. Essentially, all homeless women return to the abuser at some point of time for financial reasons and all economically independent women leave the system for good. Effectively, this is a system with only one exit, and the success rate of exiting depends on the positiveness of support systems.

Figure 3 depicts an eight-shaped diagram of decision rules for an individual woman as she is navigating through the system.

Figure 3. A Representation of Decision Rules for an Individual Woman².



² Numbers in red correspond to the equation number (see Chapter 4), where:
 4 & 5 = probability of violence (p. 61)
 7 = probability of help (p. 63)
 12 = probability of visiting a shelter (p. 65)
 14 = probability of finding a job for a low-income woman (p. 66)
 15 = probability of visiting a community service center (p. 67)
 18 = probability of leaving the relationship (p. 68)

The journey begins in the middle of the diagram, i.e., if a woman experienced some violence. From this point she may depart down and to the left and make a decision to leave. If a woman does not have enough resources she continues along the circle to the right essentially making it back to the original point of departure.

A woman may also decide to move up and to the left or up and to the right (to use social resources). The helpfulness of these resources is one of the factors at play in the lower part of the diagram (becoming homeless). On the other hand, services aimed at education, employment and child care may help a woman to obtain a full-time job and higher income may decrease the rate of violence. While an exit point it not explicitly shown here (unlike **Figure 2**), it is assumed that if a woman is economically independent she leaves the system.

2.7 Conclusion

Here, I have presented a conceptual model based on the literature review that links intimate partner violence, formal and informal support systems and women's socio-cultural and economic background. I assumed that economic independence reduces the chance of domestic violence as women with more resources have more power, including the power to leave. As women navigate through system attempting to gain independence, their success rate depends on the overall positiveness of the response.

In the next chapter I will review the literature on agent-based modeling and discuss the reasons for using this methodology, including its advantages and disadvantages.

Chapter 3: Agent-Based Modeling

Here, I present literature review on agent-based modeling (ABM) and discuss the components, the use, advantages and disadvantages of the method. Despite many limitations related to validation, verification and justification of models built to represent social systems, ABMs appear to be a useful method for understanding the dynamics of domestic violence and simulating policy changes.

3.1 Models and Their Use

A model is essentially a simplified representation of some reality (Castle and Crooks 2006). As Gilbert and Terna (2000:57) put it, “almost all social science research proceeds by building simplified representations of social phenomena. Sometimes these representations are purely verbal. In other fields the representation is usually much more formal and often expressed in terms of statistical or mathematical equations”. For Axelrod (2005:1574), creating a model is a form of art: “I see a further connection between art and modeling. My father painted to express how he saw the world that day, highlighting what was important to him by leaving out what was not. Likewise, I see my modeling, especially my agent-based modeling, as an expression of how I see some social dynamic, highlighting what I regard as important, and leaving out everything else”.

Until recently, computer simulation has been less common in social sciences because “the principal value of simulation in social sciences is for theory development rather than for prediction” (Gilbert and Terna 2000:59), as opposed to natural and engineering sciences, which use simulation for making future predictions. However, the development of agent-based models

has brought more interest in using this methodology in social sciences. One of the major reasons of an increasing interest in using ABMs is the growing complexity of the world in terms of relationships and their interdependencies (Macal and North 2009). However, no matter how ‘simple’ a social system appears to be, it is ‘complex’ by the mere definition of being a social system. Herein lays one of the major advantages as well as major challenges of using ABMs over other methods, as will be discussed in the next section.

According to Castle and Crooks (2006), models can be of two general types: explanatory and predictive. *Explanatory* models do not attempt to mimic a real-world system but rather concentrate on some aspect of the system and try to investigate theory and create hypotheses (de Smith, Goodchild and Longley 2009). On the other hand, *predictive* models mimic real-world systems and can be used for testing policies, doing forecasting, extrapolating trends and creating “what if” scenarios. According to de Smith, Goodchild and Longley (2009) these two types are not mutually exclusive and depend on the purpose of the model, the required precision, available data and information.

In their discussion of modeling as applied to social sciences, Brown and Harding (2000) concentrate on predictive models and their applications to government policies and suggest a more detailed typology. Thus, models can be *quantitative*, driven by the empirical data and designed in mathematical or statistical terms. *Quantitative* models can be implemented in spreadsheets, special software or programming code (Macal and North 2009). On the other hand, *qualitative* models are based on “subjective measurement or normative approaches” (Brown and Harding 2000). Unlike *dynamic* models, *static* models do not model a time sequence of changes and “measure the effects of policy changes on the ‘morning after’ the change”, i.e. they assess

the immediate influence of the policy on a person (Brown and Harding 2000). Dynamic models, on the other hand, allow us to update the characteristics of the individuals every time step.

Furthermore, Brown and Harding (2000) distinguish between *deterministic* or *stochastic* models. *Deterministic* models are rule-based, meaning an event A is scheduled to happen in some relation to event B, while *stochastic* models are based on probabilities that a given event will occur. Next, *non-behavioral* models do not allow the individual change their behavior in response to policy change, while *behavioral* models are more complex and require understanding on how people will react in given circumstances. Finally, *spatial* models identify individuals within a geographical space, regardless of whether or not the individuals move within the space.

Brown and Harding (2000) conclude that in order for a model to be useful it is necessary to recognize what type of model is needed and whether the model meets the requirements of the users. According to Louie and Carley (2008), the usefulness of multi-agent models as applied to social sciences starts with the recognition that such models demonstrate and explore the relations in the system and may help to develop other mental models or enhance the existing ones or explore what yet unknown factors can influence the system.

3.2 ABMs: Description and Advantages

Agent-based modeling is one of the formal ways to represent reality. Agent-based modeling (ABM) is also known under the terms of Agent-Based Computational Modeling, (ABCM), Agent-Based Social Simulation (ABSS), Agent Based Computation Simulation (ABCS), Agent-Based Modeling and Simulation (ABMS), Individual-Based Modeling (IBM) and Multi-Agent Systems or MAS (de Smith, Goodchild and Longley 2009).

Agent-based modeling is a simulation technique that “refers to the use of computational methods to investigate processes and problems viewed as dynamic systems of interacting agents” (de Smith, Goodchild and Longley 2009). In ABMs, autonomous agents are real-world entities that comprise the system (Bonabeau 2002). Agents follow a set of rules and make appropriate decisions thus mimicking the behavior of individuals in a system. There is not a specific definition of an agent (de Smith, Goodchild and Longley 2009) though the following properties usually apply: autonomous, self-directed, modular, self-contained, social and interacting, living in an environment, having goals that drive the behavior, able to learn and adapt, heterogeneous (Macal and North 2009), engaged in local interactions, having bounded rationality (i.e., making decisions on the basis of the local information) and having emergent behavior (Eipstein 1999).

Emergent behavior and ability of ABMs to produce emergent phenomena are cited as one of the advantages of the method, especially in relation to theory development. Gilbert and Terna (2000:61) describe emergent phenomenon as when “some patterns arise at the level of the system as a whole that are not evident from consideration of the capabilities of the individual agents”. It can be recognized when chaos occurs or when instead of an equilibrium state the model depicts some cyclical behavior, which is essentially hidden in the rules governing agents’ behavior (Gilbert and Terna 2000).

Other advantages of ABMs can be placed into two general categories: first, the relative ease in representing reality and second, the ethical, time, and money considerations.

Traditional models employ a top-down approach, which means that information on certain aggregate variables has been first collected and then reconstructed in the model. As a result, the top-down approach is concerned with the correlations between predicted and observed outcomes but not with the behavior of the entities that produces a given outcome. When a model is created

on an aggregate level, it is problematic in that it focuses on heterogeneity, interaction, process or representation of dynamics (Bonabeau 2002; Castle and Crooks 2006). ABMs employ a bottom-up approach that is concerned “ . . . with modeling agent relationships and agent interactions as much as it does modeling agents and agent behaviors” (Macal and North 2009:93).

According to Gilbert and Terna (2000), representation of some social phenomena, which often has non-linear relationships, via mathematical and statistical models may be difficult because these models can become too complicated and may not be analytically tractable. The equations can be simplified in order to solve them but this can lead to misleading theories, an example of which is an assumption of perfect information in economics (Gilbert and Terna 2000). Differential equations also make it difficult to describe complex individual behavior and such representation may become intractable (Bonabeau 2002). Axtell (2000) mentions the following advantages of ABMs over mathematical modeling: agents’ rationality may be limited; heterogeneity of agents helps overcome their rationality; and there is an entire dynamic history of the process being modeled. The last but very important factor is the ability of ABMs to represent physical space and social networks which are difficult to represent mathematically (Castle and Crooks 2006).

As ABMs are usually implemented with a computer code, programming also makes it easier to represent non-linear relationships (Gilbert and Terna 2000). Castle and Crooks (2006) further mention the following advantages of using a computer simulation: programming languages are less abstract; as opposed to a system of mathematical equations there is no need to define an order of actions; and existence of modularity (i.e., it is possible to change portions of the code without changing the whole system).

As a result, ABMs employ useful details which make the representation of the system more realistic. This is a valuable consideration in applying the method to the issue of intimate partner violence. This method appears to be well suited for studying help-seeking behavior of battered women who come from a variety of social, economic and ethnic backgrounds and consequently do not have a set of one-fit-all coping strategies. The method is also suited for mimicking help-providing behavior of informal and formal systems who themselves are guided by a variety of cultural, social and economic considerations.

ABMS also make very good statistical data at a fine resolution (Parker et al. 2003). Regarding research on intimate partner violence, statistical regressions provide information on the correlation between a set of some factors and a probability of violence, as well as correlation between violence and a chance of homelessness or employability (among others) yet very rarely if at all the regressions are combined in a dynamic system. In addition, many of the statistical models are sampled-based and exclude insufficiently represented individuals from a final model. As cited by Crenshaw (1997:99) “a researcher qualified the statistics of one survey by pointing out that ‘an unknown number of minority women were excluded from this survey sample because of the language difficulties’”. The use of ABMs may thus help to encounter hidden ‘statistics and people’, such as the responses to violence of women from immigrant and ethnic communities. As Castle and Crooks (2006) note, one of the motivations for constructing the model is because the target is not easily accessible. In this regard, ABMs can be used as a tool for presenting mathematical results to policy-makers (Axtell 2000).

ABMs are thus a virtual laboratory in which agents can be assigned different attributes and rules. This is further useful from a perspective of ethics, costs, timeliness and appropriateness (Louie and Carley 2008). Running a real-world experiment may put actual people at risk in some

cases and in other cases it may take too much time to run an experiment or a collection of data may be too expensive. Quite clearly, the issue of intimate partner violence satisfies all of these requirements. Nation-based studies on intimate partner violence cannot be conducted every year and researchers either use relatively small non-population based samples or have no choice but to use ‘old’ data. For example, Basu and Famoye (2004) combined two surveys, one conducted in 1974 and another one in 1992-1994s. One of the reasons was that neither survey provided necessary data hence combination of the two was necessary. Finally, testing policies on people already experiencing violence may put them at even higher risk.

As a concluding remark on when to use ABMs as opposed to other methods, Macal and North (2009:96) provide a ‘checklist’ of criteria:

- When the problem has a natural representation as being comprised of agents
- When there are decisions and behaviors that can be well-defined
- When it is important that agents have behaviors that reflect how individuals actually behave
- When it is important that agents adapt and change their behaviors
- When it is important that agents learn and engage in dynamic strategic interactions
- When it is important that agents have a dynamic relationship with other agents, and agent relationships form, change and decay
- When it is important to model the processes by which agents form organizations, and adaptation and learning are important at the organization level
- When it is important that agents have a spatial component to their behaviors and interactions

- When the past is no predictor of the future because the processes of growth and change are dynamic
- When scaling-up to arbitrary levels is important in terms of the number of agents, agent interactions and agent states
- When process structural change needs to be an endogenous result of the model rather than an input to the model

3.3 ABMs: Limitations and Disadvantages

As any method, ABMs have a number of disadvantages. Castle and Crooks (2006) note that the model is only useful for the purpose it has been constructed and hence it needs to be built at a right level and with the right amount of detail. Furthermore, social systems are difficult to quantify, calibrate and justify and for this reason are difficult to implement and interpret (Castle and Crooks 2006). Axtell (2000) mentions that in order to test the robustness of the model it is necessary to perform many runs while changing initial conditions or other parameters. In terms of implementation, it is essential to be careful with the computer code, as computer ‘bugs’ tend to appear regardless of how cautious a model builder is. As a result, it is necessary to watch out for ‘artifacts’ or ‘phantoms’, i.e. erroneous results due to computer ‘bugs’ (Axtell 2000; Gilbert and Terna 2000). For example, it is possible that an unexpected result is due to an error in a code rather than an unexpected outcome of the model.

The model must be validated and at first, an inner validity must be present, i.e., the model should behave as expected (Castle and Crooks 2006). Overall, there are different degrees of validity. Louie and Carley (2008) discussed in details the problem of validation since validation techniques have been developed in engineering fields on the basis of physical laws but they

cannot be applied directly to social phenomena, which are not governed by universal laws.

Below is the chart of types of validation, adopted after Louie and Carley (2008):

Table 1. Types of Model Validation

Types of Validation	Conceptual	Representative Proper algorithms
	Operational	Calibration Replication Forecasts Hypothetical Intervention
	Data	Sensitivity to parameter bias

As Louie and Carley (2008) explain, *conceptual validation* means the extent to which the model theories, assumptions, entities and relationships between them are appropriate for the purpose of the model. At this level, the model can be used for qualitative insight. *Operational validation* means the extent to which the results of the model correspond to the observed real-world data or system. Thus, calibration shows the extent to which the model reproduces the actual system and can be done using historical data (how well it reproduced past events) and prospective data (how well the future conditions will be predicted). A calibrated model may actually be used for quantitative forecasting and predictions.

Finally, *data validation* determines whether the data are appropriate for the purpose of the system and whether the data are accurate in comparison with the real world system. The problem is that the quality and availability of data may create certain constraints on the development of

the model. This is one of the challenges of modeling social systems – it is difficult to quantify and validate the model. Castle and Crooks (2006:39) mention that the purpose of a sensitivity analysis is “to determine the extent variation in the model’s assumptions yield differences in the model output”. The problems here are that if the model is very sensitive to small differences in parameters it is possible that these values are incorrect. On the other hand, conducting sensitivity analysis requires time and computational resources.

According to Castle and Crooks (2006: 15), “varying degrees of accuracy and completeness in the model inputs determine whether the output should be used purely for qualitative insight, or accurate quantitative forecasting”. As further cited by Castle and Crooks (2006:18), “any model with positive feedback can create system behavior referred to as path dependence; where a path to a process can be very sensitive to both initial conditions and small variations in stochastic processes”. Furthermore, using too much real-world data can make the model overly fitted and the model can become too general for analyzing alternative systems or for representing outcomes from the system.

3.4 Conclusion

In this chapter I presented what an agent-based model is, its limitations and advantages. Agent-based modeling is suited for studying help-seeking behavior of battered women who come from a variety of social, economic and ethnic backgrounds and consequently do not have a set of one-fit-all coping strategies. The method is also suited for understanding help-providing behavior of informal and formal systems that are guided by cultural and economic constructs. In addition, this method is suitable in situations when it is not possible to perform real-world experiments

due to ethical, time, or money concerns. Furthermore, agent-based modeling has the potential to reveal hidden “statistics and people” to policy makers.

While it is problematic to validate, calibrate and justify a model built on the basis of a social system, one of the purposes of the model is to demonstrate and explore the relations in the system. As such, it can help develop other mental models or enhance the existing ones.

Chapter 4: Methodology

In this chapter I discuss the methodology employed to collect data on Chicago's social services and to create digital representation of Chicago's population on the basis of American Community Survey (ACS). I further elaborate on some of the issues related to the choice of the sample population for the model. Finally, I describe how I constructed the model, including basic assumptions, initial parameters, and regression functions. Specific details for each regression, including confidence intervals and p values can be found in Appendix C. I conclude the chapter with a summary of the model's assumptions.

4.1 Data Collection

I collected the data on shelters and community service centers using the websites of corresponding agencies. A list of shelters that service families, women and children is based on Landis (2007) and such web-based databases as www.shelterlistings.org, www.homelessshelterdirectory.org, www.apnaghar.org/dv/dvresource.shtml, and www.sboard.org/shelters/il.htm. Here, a definition of a shelter includes any type of housing ranging from emergency and overnight shelters to transitional housing programs. Shelters serving primarily men or people with substance abuse problems are not included in the list. The reason for including homeless shelters in addition to domestic violence shelters is that many survivors of domestic violence may want to use any shelter if a specialized shelter is not available or does not have enough space.

Next, I collected the following data on the basis of information publicly available on websites of corresponding agencies: the address of a shelter, the information on a type of a

shelter (homeless, domestic violence, interim/transitional housing or emergency), the maximum number of days an individual can stay, and the number of available beds, apartments or single occupancy rooms. I excluded those shelters with no data on the number of beds from the sample and if the maximum number of days was not available, extrapolated the numbers on the basis of information from other shelters.

Homeless shelters have their postal addresses listed on the websites however it is not the case for shelters providing domestic violence services. These shelters typically have only a phone number and a PO Box listed as contact information for privacy reasons. Whenever possible, I obtained the address of a shelter from a publicly available source. If the address was not available, I used a PO Box number to identify a location of a corresponding post office and used this address as a substitute for the shelter's address. Sometimes, an agency operating a domestic violence shelter has a main office whose postal address is publicly available. In these cases, I substituted the address of a main office for the one of a shelter. I further converted all the addresses into easting/northing UTM coordinates.

I collected the data on community service centers in the same way. A list of community service centers is based on Landis (2007) and such web-sites as www.illinoisattorneygeneral.gov/dvsa/violence_victims.html, www.apnaghar.org/dv/dvresource.shtml, www.literacychicago.org, and www.illinoisworknet.com. I also used the websites of these agencies to collect information on the location of the community service center, and on the availability of the following services: housing, education (GED and ESL), child care and financial assistance. If the service was present I coded as 1 otherwise 0. If it was not clear whether a given community center provides any of these services, I eliminated it from the list.

Finally, I downloaded the shapefiles containing locations of police stations and boundaries of police beats from the Chicago City website at

www.cityofchicago.org/city/en/depts/doi/supp_info/gis_data.html.

The list of shelters and community service centers as well as the list of available services is by no means complete. However, conducting interviews with agencies' personnel and collecting very detailed data is outside of scope of this research. The purpose of my database is to represent Chicago's shelter and community service center system as realistically as possible given the time constraints. Detailed information on the list of shelters and community service centers collected for this study can be found in Appendix A and Appendix B.

4.2 Data Creation: Making the Digital Population of Chicago

I created Chicago's population using Digital Populations software (Ehlschlaeger 2004), which took in the following inputs: NLCD 2001 landcover map at 30 meter resolution (obtained from The National Map Seamless Server), a shapefile of Chicago census tracts (obtained from ESRI), 2008 American Community Survey (ACS) data on households and population (obtained from the U.S. Census Bureau, and 2009 demographic estimates by Geolytics, Inc (obtained from the Joseph Regenstein Library at the University of Chicago).

All of the input files had to be pre-processed. Chicago is covered by twenty Public Use Microdata Areas (PUMAs 3406, 3411, 3501-3519), which constitute the smallest geographical unit in ACS data. Using ArcGIS 9.2, I prepared a landcover map and a census tracts map in a raster format covering only these PUMAs. A census tract was the unit of analysis. Finally, I prepared three comma separated files: one containing 2009 demographic estimates for the census

tracts of interest and two containing ACS household and population data for the PUMAs of interest.

Digital Populations software makes it possible to create multiple realizations of population depending on the purpose of the study. Using simulated annealing, it estimates the number of household archetypes in ACS data. Digital Populations replicates each archetype a given number of times, attempting to fit it to 2009 estimates and to find the best location for a particular household. This location is based on a regression analysis of land cover by census tract to determine localized population density and the matching of census tracts' population characteristics.

The person conducting the analysis needs to specify a number of variables of interest and these variables will define the realizations. In other words, the variables of interest will be well fitted while others will be less so. Thus, household and population realizations created for a study on alcohol use among the youth will differ from those created for a study on cancer risk among elderly women.

For this research, I specified the following variables: age in increments of 5 years, race/ethnicity, ability to speak English, citizenship/nativity status and household income in increments of \$5,000. The final product is a household comma separated file and a population comma separated file, with each file containing all the information found in ACS.

Once the realization of households and population for Chicago City was ready, I extracted a 1% random sample of all households and corresponding population records. The value of 1% appears to be a maximum as it was determined experimentally on the basis of the workstation's computational power and the model design. I next resampled the total population sample to contain only people of White and Black race and Hispanic/Latino ethnicity, as defined by the

ACS. Finally, I defined married women and those living with unmarried partners as a target population at risk.

The limitation of a total sample to White/Black racial categories and Hispanic/Latino ethnicity and a target sample to married/cohabiting women is based on a number of considerations. First, the American Community Survey does not account for dating couples. As a result, it is only possible to match a female and a male only if they reside in the same household. While it may be possible to estimate how many single/widowed/separated women have dating partners and to attempt to match a dating partner on the basis of socioeconomic status or other criteria, this is a very risky proposition and requires a great deal of research before making any assumptions. This is outside of scope of this work.

Second, the majority of studies on intimate partner violence are based on samples consisting of White, Black and Hispanic/Latino race/ethnicity and therefore the data are the most accessible for these groups. Another problem is that the definitions of race may differ by study, since racial categories change with time. For example, it is not always explicit whether the category White refers to any White individual or to White Non-Hispanic only.

In this research I distinguish between White Non-Hispanic, Black non-Hispanic and Hispanic individuals. According to Sweet (personal communication 2010), people of Hispanic ethnicity very rarely identify their race as Black/African American, Asian or Native American and vice versa. Based on 2008 ACS data, it appears that the majority of Hispanic people identify themselves as White, Other or Two+ races. For this research, I initially created the following categories: White Non-Hispanic (an individual of White race and Non-Hispanic ethnicity), White Hispanic (an individual of White race and Hispanic ethnicity), Other Hispanic (an individual of Other/Two+ race and Hispanic ethnicity) and Black (an individual of Black/African American

race and Non-Hispanic ethnicity). Next, White Hispanics and Other Hispanics were combined together into one Hispanic category.

Furthermore, the majority of the literature on intimate partner violence either investigates the same-race couples or does not explicitly specify the race of each partner. One of the possible reasons is that interracial marriages, especially among the White people historically have been less socially acceptable. For example, over 1970 – 2000, interracial marriage rates have grown from 0.4 to 2.7 marriages for White people and from 1.1 to 7.0 marriages for Black people per one million people (Orbe and Harris 2008).

As such, I operate under the assumption that both partners in a couple belong to the same race/ethnicity. Since the focus of the study is on women, woman's race and ethnicity is used as a baseline (i.e., a male partner's race as specified by ACS is "overwritten" by female partner's race). I must note that as a result of these limitations, the dynamics of the model may change if one changes racial categories.

4.3 Final Model Assembly

As I discussed in Chapter 2, the model is based on the assumption that greater economic resources that woman has access to will lower the chance of domestic violence. Availability of resources is conceptualized as access to and capacity of social services.

Each battered woman's behavior is assumed to be rational and to be aimed at reducing domestic violence via utilizing social services. In other words, it is assumed that each battered woman wants to reduce or stop violence by means of becoming more economically independent (e.g., having a higher income) or by means of leaving the relationship if the violence doesn't stop. As a general rule, each battered woman may do the following actions: contact friends,

receive support from friends, contact police, find IPV services, receive assistance from IPV services, leave the relationship, become homeless (defined as not having enough personal resources to be economically independent) and go back to the relationship. Race, ethnicity, and socio-economic status of each woman as well as accessibility to and availability of services are taken into consideration and change the probability and timeliness of performing these actions. Each of these actions is represented by either a statistical regression or a fixed probability taken from the literature or by a change in a person's characteristics.

I developed the model by using NetLogo 4.1 modeling environment (Wilensky 1999). It uses four types of agents, which represent humans, police offices, shelters and community centers. The model's computational time step is a month. I've chosen this time step a) intuitively, b) due to the workspace's computational power limitations. With an exception of calling police, all other regressions operate on a yearly basis. Intuitively, it appears that a week or at least a month is a logical time step for women's making decisions over a several years period. Thus, a woman is likely to call police immediately after a violent episode but it may take weeks before she is willing to disclose abuse to friends or months and years before she is willing to leave. While a weekly time step may be more preferable, it requires a great deal of computational power. Thus, the model uses a monthly time step as the most convenient one in these circumstances.

The GIS component of the model consists of raster files defining the boundaries of Chicago and Chicago census tracts. Using NetLogo GIS extension, I first imported a boundary layer and a tracts layer into NetLogo. Both of these layers are at 90 meter resolution with a geographic projection of NAD 1983 UTM zone 16N. The coordinates and the cell size of the "real" world map are matched to the coordinates and patch size of NetLogo world, which allows me to

perform the calculations of distance in meters. Next, I exported population, police and shelter/community service records into NetLogo and mapped them according to their geographic coordinates. Finally, the percentage of population by race was calculated for each tract in order to determine racial composition of an area.

In the next sections I discuss attributes and procedures for the agents in the model. **Table 2** specifies parameters that were used in each of the equations and lists appropriate references. The column "Parameter" specifies the name of the parameter as listed in the original study.

Table 2. Model Parameters

Parameter	Dimension of Measure	Static/ Dynamic ³	Assigned Value ⁴	Reference
Probability of violence (Salari and Baldwin 2002)				
Black vs White	White = 0, Black = 1	Static	As stated in ACS ⁵	Salari and Baldwin 2002
Hispanic vs White	White = 0, Hispanic = 1	Static	As stated in ACS	
Household Income	Tenths of thousands	Dynamic	As stated in ACS	
Female Income, %	Female income / Household Income * 10	Dynamic	As stated in ACS	
Male Traditional Role	Traditional = 1, 0 otherwise	Static	50% likelihood	
Female Traditional Role	Traditional = 1, 0 otherwise	Static	42.5% likelihood	
Dependent Child Under Age 5	Yes = 1, 0 otherwise	Static	As stated in ACS	
Cohabiting vs. Married	Cohabiting = 1, married = 0	Static	As stated in ACS	
Male Family Contacts	Range from 0 to 3+	Static	<u>Contacts / Likelihood</u> 0 2% 1 6% 2 8% 3 11% 4 11% 5 17% 6-9 18% 10+ 27%	Carroll 2004

³ Static refers to the variables that are set during the setup and do not change during the simulation. Dynamic refers to the variables that change during the simulation either due to a random choice or a result of changing parameters.

⁴ If the dimension of measure is a range or a scale, the values in the Assigned Value are computed accordingly to match the scale in the original regression

⁵ ACS refers to the 2008 American Community Survey

Table 2 (cont.)

Parameter	Dimension of Measure	Static/ Dynamic	Assigned Value				Reference
Female Family Contacts	Range from 0 to 3+	Static	Same as Male Contacts				Carroll 2004
Social Outings	Scale 0 to 4	Static	<u>Scale / Range of Contacts</u>				
			0	0			
			1	1 – 5			
			2	6 – 10			
			3	11 – 15			
			4	16+			
Crisis Support	Present = 1, 0 otherwise	Dynamic	1, if a person received informal support				
Female Alcohol Problem	Present = 1, 0 otherwise	Static	<u>Age</u>	<u>White</u>	<u>Black</u>	<u>Hispanic</u>	Grant et al 2004
			18-29	5.56%	2.1%	3.04%	
			30-44	4.13%	1.51%	1.46%	
			45-64	2.02%	1.25%	0.63%	
			65+	0.36%	0.12%	0.0%	
Male Alcohol Problem	Present = 1, 0 otherwise	Static	<u>Age</u>	<u>White</u>	<u>Black</u>	<u>Hispanic</u>	Grant et al 2004
			18-29	10.19%	6.92%	9.08%	
			30-44	10.1%	7.04%	4.88%	
			45-64	5.97%	4.48%	4.35%	
			65+	2.38%	1.79%	3.69%	
Male Esteem	Scale from 0 to 3	Static	<u>Scale / Likelihood</u>				Salari and Baldwin 2002
			0	4.9%			
			1	7.8%			
			2	20.9%			
			3	66.3%			
Female Esteem	Scale from 0 to 3	Static	<u>Scale / Likelihood</u>				Salari and Baldwin 2002
			0	3.9%			
			1	7.6%			
			2	21.3%			
			3	67.1%			

Table 2 (cont.)

Parameter	Dimension of Measure	Static/ Dynamic	Assigned Value	Reference
Relationship Duration	Years	Static	Set equal to when a woman moved into this house or apartment on the basis of ACS data	
Probability of calling police (Felson et al. 2005)				
The use of gun	Present = 1, 0 otherwise	Dynamic	4.8% likelihood	Felson et al. 2005
The use of other weapon	Present = 1, 0 otherwise	Dynamic	12% likelihood	Felson et al. 2005
The use of alcohol by offender	Present = 1, 0 otherwise	Dynamic	Set equal to Male Alcohol problem	
The use of alcohol by victim	Present = 1, 0 otherwise	Dynamic	Set equal to Female Alcohol Problem	
Physical injury	Present = 1, 0 otherwise	Dynamic	Set to 1 if a violence act happens	
1-4 victimizations	Present = 1, 0 otherwise	Dynamic	Set to 1 if a count of violent acts is within 1-4 range	
5 or more victimizations	Present = 1, 0 otherwise	Dynamic	Set to 1 if a count of violent acts is over 5	
Victim high income (>= \$40,000)	Present = 1, 0 otherwise	Dynamic	As stated in ACS	
Victim low income (<= \$25,000)	Present = 1, 0 otherwise	Dynamic	As stated in ACS	
Victim Black	Present = 1, 0 otherwise	Static	As stated in ACS	
Victim Hispanic	Present = 1, 0 otherwise	Static	As stated in ACS	
Victim age 30+	Present = 1, 0 otherwise	Static	As stated in ACS	

Table 2 (cont.)

Parameter	Dimension of Measure	Static/ Dynamic	Assigned Value	Reference
Victim age below 18	Present = 1, 0 otherwise	Static	As stated in ACS	

Probability of leaving abuser (Sabina and Tindale 2008)

Number of Incidents per year	From 0 to ∞	Dynamic	Count of annual violent acts	
Range of Incident Severity	Scale from 1 to 6	Dynamic	<u>Scale / Likelihood</u> 1 9% 2 22% 3 23% 4 22% 5 13% 6 11%	Block 2000
Harassment Level	Scale from 0 to 19	Dynamic	<u>Scale / likelihood</u> 0 21.5% 1 12.7% 2 9.3% 3 8.7% 4 6.4% 5 8.4% 6-10 24.3% 11-19 8.7%	Block 2000
Power and Control Level	Scale from 0 to 5	Dynamic	<u>Scale / Likelihood</u> 0 16.8% 1 14.5% 2 11.8% 3 15.1% 4 16.7% 5 25.1%	Block 2000

Table 2 (cont.)

Parameter	Dimension of Measure	Static/ Dynamic	Assigned Value	Reference
General Health	Scale from 1 to 5	Dynamic	<u>Scale / Likelihood</u> 1 7.6% 2 29.8% 3 35.5% 4 15.8% 5 11.3%	Block 2000
Lack of Depression	Scale from 0 to 5	Dynamic	<u>Scale / Likelihood</u> <u>Hispanic</u> <u>Non-Hispanic</u> 0 24.5% 42.6% 1 11.3% 21.3% 2 16.4% 11.9% 3 18.9% 12.3% 4 13.2% 8.3% 5 15.7% 3.7%	Block 2000
Education Level	Range from 1 to 9, where: 1 = no schooling; 2 = elementary school; 3 = some high school; 4 = GED; 5 = some college; 6 = community college or similar; 7 = four-year college; 8 = some graduate school; 9 = graduate or professional degree	Dynamic	As stated in ACS	
Personal Income	Range from 1 to 9 in increments of \$5,000	Dynamic	As stated in ACS	
Employed FT/PT, Homemaker or Student	1 if true, 0 otherwise	Dynamic	As stated in ACS	
Support Network	Scale from 0 to 12	Dynamic	Set equal to LevelOfSupport	

Table 2 (cont.)

Parameter	Dimension of Measure	Static/ Dynamic	Assigned Value		Reference
Talk to friends					
Disclose Abuse	1 if true, 0 otherwise	Dynamic	<u>Race/Ethnicity</u> White Hispanic Black	<u>Likelihood</u> 92% 74% 44%	West et al. 1998; Yoshioka et al. 2003
Determine level of support					
LevelOfSupport	Range as assigned	Dynamic	<u>Race/Ethnicity</u> White Hispanic Black	<u>Range</u> 8.55 4.11 – 6.86 4.58 – 7.42	Block 2000; Yoshioka et al. 2003
Helping survivors of IPV (Beeble et al. 2008)					
Gender	Female = 1, male = 1	Static	As stated in ACS		Beeble et al. 2008 Moracco et al. 2005
Age	Years	Static	As stated in ACS		
Attitudes/Beliefs about helping	Range from 0 to 5	Dynamic	<u>Ethnicity</u> Hispanic Non-Hispanic	<u>Range</u> 2.9 3.57 – 4.95	
Childhood exposure to IPV	1 if true, 0 otherwise	Static	37% likelihood		
Personal Exposure to IPV	Range from 0 to 15	Dynamic	Set equal to number of violent acts per year		

Table 2 (cont.)

Parameter	Dimension of Measure	Static/ Dynamic	Assigned Value	Reference
Perceived prevalence of IPV rates	Range from 0 to 5	Static	<u>Ethnicity</u> Non-Hispanic 1.86 – 4.79 Male Hispanic 2.9 Female Hispanic 4	Beeble et al. 2008 Moracco et al. 2005
Services				
Housing	As assigned	Static	1.92	Allen et al. 2004
Education	As assigned	Static	2.32	
Childcare	As assigned	Static	1.53	
Financial assistance	As assigned	Static	1.77	

Human agent

Human agents are males and females over the age of 15. At the beginning of the simulation each married or cohabiting woman is at risk for experiencing intimate partner violence by default. The probability of physical or injurious domestic violence in a couple is calculated according to Salari and Baldwin (2002) and depends on such factors as race/ethnicity, household income, female income, gender roles, availability of informal support, presence of a child under 5 years old, relationship duration, alcohol/drug problems and self-esteem. Salari and Baldwin (2002) define physical aggression as minor violence acts consisting of shoving or slapping while injurious aggression consists of such injuries as bruises or broken bones. Household income and woman's personal income are the defining factors in experiencing violence, especially of injurious nature. While factors other than income are significant as well (e.g., alcohol/drug problems, number of friends, traditional gender roles or self-esteem), currently the model assigns random values to these factors at the beginning of simulation and does not allow them to change later on. The equations for verbal, physical and injurious violence are as follows:

(1)

$$\begin{aligned} \text{Verbal Aggression} = & 0.6 + \text{Black} * 0.073 - \text{Hispanic} * 0.360 - \\ & \text{Household Income} * 0.008 - \text{Female Percent Income} * 0.001 + \\ & \text{Male Traditional Gender Roles} * 0.1 - \\ & \text{Female Traditional Gender Roles} * 0.090 + \text{Dependent Child} * 0.286 - \\ & \text{Cohabiting} * 0.539 - \text{Relationship Duration} * 0.010 + \\ & \text{Male Family Contact} * 0.012 - \text{Female Family Contact} * 0.012 + \\ & \text{Social Outings} * 0.035 - \text{Crisis Support} * 0.254 + \\ & \text{Male Drug Problem} * 0.689 + \text{Female Drug Problem} * 0.221 - \\ & \text{Male Esteem} * 0.130 - \text{Female Esteem} * 0.182 \end{aligned}$$

(2)

$$\begin{aligned}
\text{Injurious Aggression} = & 0.7 + \text{Black} * 0.166 - \text{Hispanic} * 0.079 - \\
& \text{Household Income} * 0.165 + \text{Female Percent Income} * 0.009 + \\
& \text{Male Traditional Gender Roles} * 0.473 - \\
& \text{Female Traditional Gender Roles} * 0.047 + \text{Dependent Child} * 0.422 + \\
& \text{Cohabiting} * 0.491 - \text{Relationship Duration} * 0.051 + \\
& \text{Male Family Contact} * 0.039 - \text{Female Family Contact} * 0.108 + \\
& \text{Social Outings} * 0.004 - \text{Crisis Support} * 0.339 + \\
& \text{Male Drug Problem} * 1.910 + \text{Female Drug Problem} * 1.47 - \\
& \text{Male Esteem} * 0.296 - \text{Female Esteem} * 0.403
\end{aligned}$$

(3)

$$\begin{aligned}
\text{Physical Aggression} = & -0.42 + \text{Black} * 0.662 + \text{Hispanic} * 0.035 - \\
& \text{Household Income} * 0.037 - \text{Female Percent Income} * 0.001 - \\
& \text{Male Traditional Gender Roles} * 0.007 - \\
& \text{Female Traditional Gender Roles} * 0.012 + \text{Dependent Child} * 0.430 + \\
& \text{Cohabiting} * 0.403 - \text{Relationship Duration} * 0.067 - \\
& \text{Male Family Contact} * 0.009 - \text{Female Family Contact} * 0.001 + \\
& \text{Social Outings} * 0.033 + \text{Crisis Support} * 0.063 + \\
& \text{Male Drug Problem} * 1.147 + \text{Female Drug Problem} * 0.931 - \\
& \text{Male Esteem} * 0.145 - \text{Female Esteem} * 0.306
\end{aligned}$$

The probabilities for physical and injurious aggression (verbal aggression is omitted) are calculated as:

(4)

$$p(\text{physical}) = \frac{\exp(\text{physical})}{1 + \exp(\text{verbal}) + \exp(\text{physical}) + \exp(\text{injury})}$$

(5)

$$p(\text{injury}) = \frac{\exp(\text{injury})}{1 + \exp(\text{verbal}) + \exp(\text{physical}) + \exp(\text{injury})}$$

Salari and Baldwin (2002) only estimate the probability experiencing at least one violent act in the past year but they do not estimate the number of acts. Since the model's time step is a month, the resulting probability is divided by 12 (as well as probabilities calculated for all other regressions). As such, the assumption is that each time a couple experienced some violence it is equal to one violent act. Thus, a woman may experience a maximum of 24 violent acts per year (12 physical and 12 injurious), which results in an average annual rate of 15-20 violent acts per 1,000 women. This value is in agreement with some research (Sabina and Tindale 2008) but not with the other (Crowell and Burgess 1996). Despite the fact that the value agrees with some research, it must be kept in mind that the assumption is very bold and therefore any changes in the rates of violence over time should be viewed in relative terms.

Intimate partner violence triggers other events and therefore battered women are the most active agents performing the majority of actions. Since the research is focused on the activities of battered women, all men and all other women perform only one action, that is they provide support if they are in a woman's informal network. At the beginning of the simulation each sampled woman is assigned a random number of friends ranging from zero to ten (Carroll 2004). If a woman has zero friends, the level of her informal support automatically becomes zero. If a woman experienced IPV, she can contact one of her friends and ask for help. The probability of this action is derived from the literature that researched what percentage of sampled women of a given race/ethnicity is willing to disclose abuse to friends. Due to the lack of better alternatives, these studies are used as a representative sample.

Once contacted, a friend may provide support, the probability of which I calculated according to Beeble et al. (2008) and depends on such attributes as sex, age, attitudes and beliefs about helping IPV victims, childhood exposure, personal exposure, and perceived prevalence

rate of IPV in the community. Attitudes and beliefs and perceived prevalence rates for different race/ethnicity categories are derived from the literature and used as a representative sample.

Personal exposure is equal to the number of violent acts experienced by a person during a one year period. Positive responses from friends are coded 1 and negative responses are coded 0.

Friend's support is interpreted as a crisis support and becomes an input for calculating the chance of violence (see equation 1) and the chance of leaving the relationship (see equation 17).

(6)

$$\begin{aligned} \text{Help Giving} = & -0.41 + \text{Female} * 0.17 - \text{Age} * 0.01 + \text{Attitudes and Beliefs about IPV} * 0.12 + \\ & \text{Childhood Exposure to IPV} * 0.30 + \text{Personal Exposure to IPV} * 0.35 + \\ & \text{Perceived Prevalance Rates of IPV} * 0.12 \end{aligned}$$

(7)

$$p(\text{helping}) = \frac{\exp(\text{helping})}{1 + \exp(\text{helping})}$$

Another option for a battered woman is to call police. The probability of a call is calculated according to Felson and Pare (2005) and primarily depends on such factors as woman's income, age, severity of abuse and race/ethnicity. The regression below displays only the selected variables of interests.

(8)

$$\begin{aligned} \text{Victim Reporting} = & -2.245 - \text{Partner} * 0.964 + \text{Physical Injury} * 0.999 + \\ & \text{Home} * 0.293 - \text{Age Under Eighteen} * 0.640 + \text{Age Over Thirty} * 0.356 - \\ & \text{Education} * 0.013 + \text{Black} * 0.273 - \text{Hispanic} * 0.084 + \text{Other Race} * 0.154 - \\ & \text{High Income} * 0.038 - \text{Low Income} * 0.165 \end{aligned}$$

(9)

$$\begin{aligned}
\textit{Third Party Reporting} = & -1.810 - \textit{Partner} * 1.481 + \textit{Physical Injury} * 1.020 + \\
& \textit{Home} * 0.189 - \textit{Age Under Eighteen} * 0.311 + \\
& \textit{Age Over Thirty} * 0.144 - \textit{Education} * 0.117 + \textit{Black} * 0.070 + \\
& \textit{Hispanic} * 0.032 + \textit{Other Race} * 0.151 - \textit{High Income} * 0.137 - \\
& \textit{Low Income} * 0.135
\end{aligned}$$

(10)

$$p(\textit{victim reporting}) = \frac{\exp(\textit{victim reporting})}{1 + \exp(\textit{victim reporting}) + \exp(\textit{third party reporting})}$$

While I initially planned to estimate the positiveness of police response on the basis of how often they provide referrals to women of different racial groups and its role in changing rate of domestic violence, for the purposes of making the model less complicated the current version only employs police as an agent for collecting statistics on calls by race and by police district. Statistics on calls made to police are considered “official” measure while statistics on the number of incidents are considered “real” measure.

Another option for a battered woman is to use domestic violence services, represented by shelters. First of all, the probability that a woman will visit a shelter depends on the distance and how comfortable she is visiting the shelter. Thus, the distance decay function takes the following form:

(11)

$$P_{mk} = 0.525e^{-0.11D_{ij}},$$

where P_{mk} is the percentage of trips for mode m and purpose k and D_{ij} is the distance in kilometers between a woman i and a shelter j . The parameters for this function are fitted to automobile trips

to health care clinics on the basis of Minneapolis data (Iacono et al. 2008) and for the lack of better alternatives, I assumed they are representative of shelter visits.

I name the level of comfort “cultural sensitivity” (P_{cs}), which represents the willingness of a woman to use a particular shelter depending on its location. As I discussed in Chapter 2, some authors propose that minority women may be less willing to use shelters outside of the community or if the shelters are located in primarily White neighborhoods. It is logical to assume that White women may be less willing to use a shelter located in a primarily Non-White neighborhood. As such, I define racial/ethnic composition of each census tract on the basis of Turner and Hayes (1997): predominantly Black tracts are those where more than 50% of the population is African American; predominantly White tracts are those with less than 10% of African Americans and less than 10% of Hispanics; mixed tracts are those where African American population is between 10 and 50%; and Hispanic tracts are those with less than 10% of African Americans and more than 10% of Hispanics.

Since only anecdotal data on the willingness of women to use shelters are available, cultural sensitivity is represented arbitrarily as a value ranging from 0 to 100%. In other words, if cultural sensitivity is at 100%, the decision to use a shelter becomes only a function of a physical distance. Thus, the final conditional probability equation takes the following form:

(12)

$$p(\text{shelter visit}) = P_{mk} * P_{cs}$$

At the beginning of each search episode, a woman selects a closest shelter and assesses the probability of a visit based on a distance between her and a shelter. Then she determines her level of comfort on the basis of racial/ethnic composition of a tract where the shelter is located.

Thus, all women will be equally likely to use a shelter if it is in a racially mixed tract. Depending on what value is chosen to determine cultural sensitivity, the probability of visiting a shelter may differ for women whose race/ethnicity does not match the racial composition of a given tract.

If a woman visited a shelter, she requests a bed. If she does not obtain a bed this is considered a failure and she moves on to the next closest shelter and repeats the process until she finds an available bed, at which point she stops and stays at the shelter for a maximum possible time.

Woman's income is one of the major predictors for being at risk of violence in general and being able to leave the relationship and not to become homeless in particular. Therefore, it is necessary to represent some possibility that a woman can find a job. This probability is calculated on the basis on Blumenberg's study (2002):

(13)

$$\begin{aligned} \text{employment} = & -0.372 - \text{Education} * 0.718 - \text{Language Difficulty} * 0.386 - \\ & \text{Travel By Transit} * 0.810 - \text{Childen In Need For Care} * 0.266 - \\ & \text{Health Problems} * 806 \end{aligned}$$

(14)

$$p(\text{employment}) = \frac{\exp(\text{employment})}{1 + \exp(\text{employment})}$$

According to Blumenberg (2002), women with less than high school education, with English language difficulty, without a personal car, with personal health problems and those in need of childcare have more difficulty finding employment. Here, I interpret personal health problems as exposure to IPV on the basis of discussion provided in Chapter 2. Educational

assistance (including language training) and child care are services that can be provided by community service centers. Therefore, it is necessary to represent the probability that a woman will visit a given community service center in an attempt to improve her employability. If a low-income unemployed or underemployed woman at or below poverty level (i.e., poverty level less than or equal to 100) finds a job I assume that her annual income will be \$16,640 as based on Illinois's minimum wage of \$8.00/hour for a 40-hour work week (reported by the U.S. Department of Labor, <http://www.dol.gov/whd/minwage/america.htm>).

The visits to community service centers are a little bit different from visits to shelters as they are not restricted to battered women only. The primary purpose of a center is to provide assistance in terms of educational and other services so that low-income unemployed women or those with income at or below the poverty level will have a better chance of finding a job and hence increasing financial independence. Community centers may provide general counseling and other forms of help but only shelters have services specifically aimed at survivors of domestic violence. The probability of visiting a community center is calculated according to:

(15)

$$P_{ij} = \frac{A_j D_{ij}^{-\beta}}{\sum_{j=1}^n A_j D_{ij}^{-\beta}},$$

where A_j is the attractiveness of a community center, D_{ij} is the distance in kilometers and β is a coefficient equal to 1. Attractiveness of a community center is calculated as

(16)

$$A_j = \sum WS,$$

where W is a service and S is a coefficient representing perceived usefulness of a given service (Allen et al. 2004). Each service (i.e., education services; housing assistance; childcare; and financial aid) is coded as 1 if present and 0 if absent.

At any point during the simulation a woman may decide to leave an abusive relationship and the probability of making this decision depends on her education, personal income, the number of violent episodes and the level of informal support among others (Sabina and Tindale 2008).

(17)

$$\begin{aligned} \text{Leaving Abuser} = & -2.215 - \text{Log Incidents In Year} * 0.31 + \\ & \text{Most Severe Incident} * 0.03 + \text{Harassment} * 0.14 + \\ & \text{Power And Control} * 0.23 + \text{Health} * 0.20 - \text{Lack Of Depression} * 0.01 + \\ & \text{Education Level} * 0.10 - \text{Personal Income} * 0.02 - \text{Employment} * 0.19 - \\ & \text{HomeMaker} * 1.75 - \text{Student} * 0.25 + \text{Support Network} * 0.02 \end{aligned}$$

(18)

$$p(\text{leaving}) = \frac{\exp(\text{leaving})}{1 + \exp(\text{leaving})}$$

Clearly, women with no income or poor formal education are economically dependent on their partners and have a lower chance of leaving the relationship. On the other hand, higher incidents of violence increase the probability of leaving. If a woman eventually leaves, there is a chance she will become homeless meaning she does not have enough resources to obtain independent housing. Here, I assume that if a woman's income is less than \$16,640 and she is at or below poverty level she will become homeless. Likewise, women with similar characteristics will become homeless upon leaving the shelter. If a woman becomes homeless she utilizes community centers again hoping to obtain housing assistance or financial assistance. It is

assumed that as soon as a homeless woman finds a community center that either provides housing or financial assistance she will stop being homeless. Alternatively, she may also attempt to enter a shelter again thus competing with other ‘first-comers’.

I assign an arbitrary random value of up to 12 time-steps for each homeless woman during which she is attempting to find a bed in a shelter or housing assistance through a community service center. During this time each homeless woman may also find a job. If she does not succeed in finding housing assistance or if she does not find a job and her income is less than \$16,640 I assume she will go back to her partner.

Police agent

Police agents are simplified entities that respond to calls. I currently assume that police always respond to a call and/or arrive to the scene where the IPV has occurred. As I discussed above, police collect statistics on calls, which are considered to be “official” statistics on the rates of violence.

Shelter/community service agent

These agents respond to the requests of women and grant services depending on their availability. Regarding shelters, current model takes into account only the number of beds and a maximum time of stay. If a woman receives a bed, a shelter consequently decreases the number of available beds by one. If the number of requestors is higher than the number of available beds, a shelter will make a random choice as to whom to provide a bed. Once in a shelter, a woman is allowed to stay for a maximum possible time during which she is considered to be safe.

The estimated number of total shelter beds initially available to battered women is two. Since the model does not specifically distinguish between various types of shelters, I use the total sample which contains 3,337 beds in order to calculate this estimate.

According to the Chicago Coalition of the Homeless, 73,656 people were homeless in a fiscal year 2006, which constitutes approximately 2.6% of Chicago's 2006 population (2,833,321 people as estimated by the U.S. Census Bureau). Thus, the ratio of 3,337 beds to 73,656 people is 0.045 beds per person. The Chicago Coalition of the Homeless also reports that there were 32,105 single homeless adults and 12,007 homeless adults in families, which constitutes 60% of all homeless population, with women constituting 33% of all homeless population. For my 1% sample (a total of 30,537 persons), this translates into 794 homeless people ($30,537 * 2.6\%$), 475 adults ($794 * 60\%$), 157 women ($794 * 33\%$) and 35 women ($157 * 22\%$) whose homeless status is an immediate result of domestic violence, as reported by Levin et al. (2004). Finally, the value of 2 is a result of multiplying 35 by 0.045. I thus assume that for a 1% sample approximately two shelter beds are potentially available for women who became homeless due to domestic violence incidents. Since children are not explicitly taken into account in the model, the assumption is that one bed can be given to one woman regardless of the number of children she has.

Community centers grant services to women in a much more simplified way. Due to the lack of data on how many people each center can serve (e.g., how many spots are available in GED classes or in childcare programs or how many people can receive housing assistance or how long it takes to receive housing assistance etc), the model currently assumes that each woman automatically receives a given service if it is available at the location. Education and child care services are assigned an arbitrary time clock which determines how long a woman can use this service. For example, if a woman got into a GED class, the time clock is 12 time-steps

which means that a woman is not available for a job search until she graduates. If a woman receives childcare services, the time clock is 12 time-steps as well as a way to represent some uncertainty regarding how many children a program can serve. Other services do not have a time limit.

4.4 Summary of Model Assumptions

The assumptions of the model may be summarized as follows:

- violence can happen between two intimate heterosexual partners
- when violence happens, women are more likely to suffer physically
- women have fewer opportunities than men to end violence by means of becoming economically independent
- access to and availability of resources, defined as social services (agencies and shelters) and informal services (friends' support), are a defining factor in becoming economically independent
- no births, deaths or aging
- total sampled population is all adults (over the age of 15) of White and Black race and Hispanic ethnicity
- subsampled population at risk is all females in married or cohabiting households
- a man can provide help if he is one of the woman's friends
- only women can leave the relationship, ask for help, call police, visit shelters/community service centers, become homeless and return to the relationship

The model's structure may be summarized as follows:

- each simulation runs for 11 years
- the first year of each run is omitted from the analysis in order to let the system “warm up”
- 30 simulation runs are made for each parameter change
- the time step is one month
- aggregate statistics are compiled for White Non-Hispanics, Black Non-Hispanics,

All Hispanics and total population per 1,000 women:

- annual incident rate
- annual police calls
- initial parameters for services include:
 - 2 available shelter beds in 2 shelters
 - 60 community service centers that provide housing assistance (8.3%), ESL classes (80%), GED classes (76.6%), financial assistance (13.3%), and children services (8.3%).

4.5 Conclusion

I have presented the methodology employed to collect data on social services in Chicago and the methodology employed to generate digital population of Chicago. I further identified some of the problems related to the choice of a sample, specifically in terms of race, ethnicity and marital status. The model presented here is based on a number of statistical regressions and

fixed probabilities taken from the literature. The goal is to predict how the IPV rates change as a function of availability of services and informal support. The results are provided in Chapter 5.

Chapter 5: Results

In this chapter, I present the results of the agent-based model developed in Chapter 4. I examine how the choice of parameters, specifically, the availability of shelters beds and the level of cultural sensitivity and public awareness influence the annual rate of domestic violence for White, Black and Hispanic women as well as for all sampled women in total. While some policies may have a diminishing effect on IPV rates in general it is possible that women from certain socioeconomic and cultural environments will continue experiencing violence.

5.1 Parameters

I tested the model for three variables: the number of shelter beds, the level of cultural sensitivity (CS) and the level of public awareness (PA). As I discussed in Chapter 4, cultural sensitivity determines the willingness of women to visit shelters on the basis of women's race or ethnicity. I use the term 'public awareness' to refer to the willingness of women to disclose abuse to friends and to the willingness of friends to provide assistance.

Each variable was tested for three parameter changes which resulted in a total of 27 parameter combinations. Due to time limitations, it was only possible to run simulations for extreme parameter changes. Thus, I tested the number of shelter beds at 0%, 100% and 200% increase, and tested both cultural sensitivity and public awareness at 0%, 50% and 100% increase. While my model also takes into account the availability of services in community centers, I did not test this parameter due to time constraints and kept it constant.

The small sample size of population limited the number of shelter beds to be tested and constrained the total number of shelters to which the beds can be assigned. As I estimated in

Chapter 4, two shelter beds can be potentially available to the survivors of domestic violence for a 1% sample of Chicago population. Therefore, in order to examine what effect the lack of shelter beds may have on IPV rates, the choice of parameters becomes limited to zero and one shelter bed. The small sample size of population also complicates the decision regarding what shelters to choose.

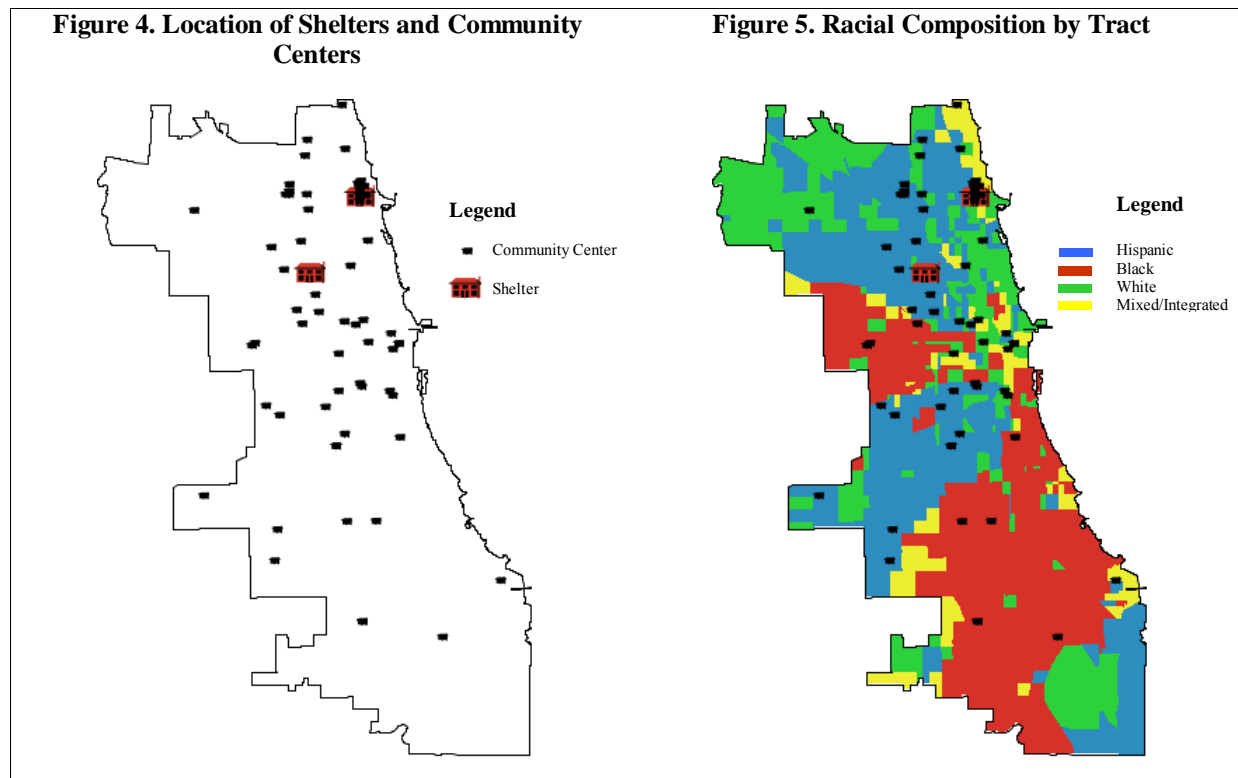


Figure 4 shows the locations of community centers and two chosen shelters. **Figure 5** shows the racial composition by tract as defined in Chapter 4 and as it appeared in NetLogo. One of the problems was whether to test one shelter location with two, four and six beds (0%, 100% and 200% increase, consequently) or more than one shelter location with number of beds distributed accordingly. In either case, the decision must be made regarding the location of the shelter(s) and the results of the model must be interpreted accordingly. The same consideration

would apply to the choice of community centers if the availability of services was one of the tested parameters. However, unlike availability of beds in the shelters, availability of services in centers is treated as a binary variable and therefore only the location of a center would be taken into account.

I kept the location of the shelters constant and only varied the number of beds (1, 2 and 3 beds in each shelter for 0%, 100% and 200% increase). As **Figure 5** shows, one of the shelters is in a predominantly Hispanic tract while the other is in a mixed/integrated tract. The choice of these shelters was random.

5.2 Expectations

Expectations of the model results should be considered on the basis of demographics.

Table 3 presents the demographics of interest calculated on the basis of 1% population sample used in simulations:

Table 3. Socio-Economic Characteristics of Sampled Population

Parameter for sampled women	Percentage
Total	20.8
Black	22.9
White	48.5
Hispanic	28.5
Black <= 100 poverty	9.1
White <= 100 poverty	2.9
Hispanic <= 100 poverty	17.0

Effect of adding shelter beds

It is generally expected that higher number of shelter beds should have a diminishing effect on annual victimization rates. When women enter a shelter they become temporarily safe and the more beds are available the more women should become temporarily safe. Shelters do not have any special rules regarding whom to accept and if there are more women than available beds, a shelter will pick a random woman. However, women make decisions whether to visit a shelter on the basis of physical distance and cultural sensitivity. It may follow that shelters will not even be filled to capacity if they are located inconveniently. If so, higher number of shelter beds will not influence victimization rates.

Effect of cultural sensitivity

Cultural sensitivity influences the probability whether women will visit shelters depending on the racial composition of a tract. Cultural sensitivity should not have any effect if a shelter is located in a racially mixed/integrated tract since all women are expected to have equal probability of going there. Overall, it is generally expected that the higher cultural sensitivity is the more women will go to shelters. However, this effect is expected to be more significant regarding Hispanic and Black women who appear to have higher IPV rates and who are expected to utilize shelters more frequently. Since one of the shelters is located in a Hispanic tract and another one is located in a mixed/integrated tract, cultural sensitivity is not expected to make a noticeable impact on Hispanic women.

Effect of public awareness

Public awareness influences the probability of aggression in a household and probability of leaving the relationship. It is thus expected that if public awareness is higher, women are more likely to disclose abuse to friends and to receive informal support which lowers the chance of violence. While higher public awareness may also increase the probability of leaving the relationship, the effect of this action is not straightforward. It may have a positive effect on women who have enough resources and who will leave the system. However, it may not have any effect on women without such resources who will end up cycling through the system (relationship – left – came back). For these women, increased public awareness may work out in a combination with some form of formal support other than shelters.

5.3 Results

Since the model is stochastic, a single run cannot be interpreted as a final result. However, due to time limitations, I was only able to conduct several runs for each parameter change. I conducted 30 runs to obtain annual incident rate and annual police calls for White Non-Hispanic, Black, All Hispanics and total sampled population per 1,000 women. I conducted 20 runs to obtain the percentage of women who left the system.

I calculated annual incident rate and annual police calls as an average for every 12th month across 10 years of simulation. The percentage of women who left the system is simply the value reported at the end of the 10th year. For each simulation I report a mean, a standard deviation and a standard error (see **Table 4**). I demonstrate the results using linear regression in order to estimate whether there is a relationship between the dependent variable (IPV rates) and independent variables (parameters to be tested). The regression is supposed to show some

general trends though the limitation of the method is that it assumes a linear relationship between two variables and is highly sensitive to outliers. However, the goal of the analysis is to understand whether the relationship between two variables exists and whether it is positive or negative. In the future, it may be possible to conduct more sophisticated statistical analyses.

Figure 6 and **Figure 7** show the annual intimate partner violence rate and police calls averaged by a simulation. As the simulation number increases the value of tested parameters increases so that the first simulation number refers to the original parameter values (i.e., all three parameters were increased by 0%) and the last simulation number refers to a combination of shelter beds increased by 200% and cultural sensitivity and public awareness increased by 100%.

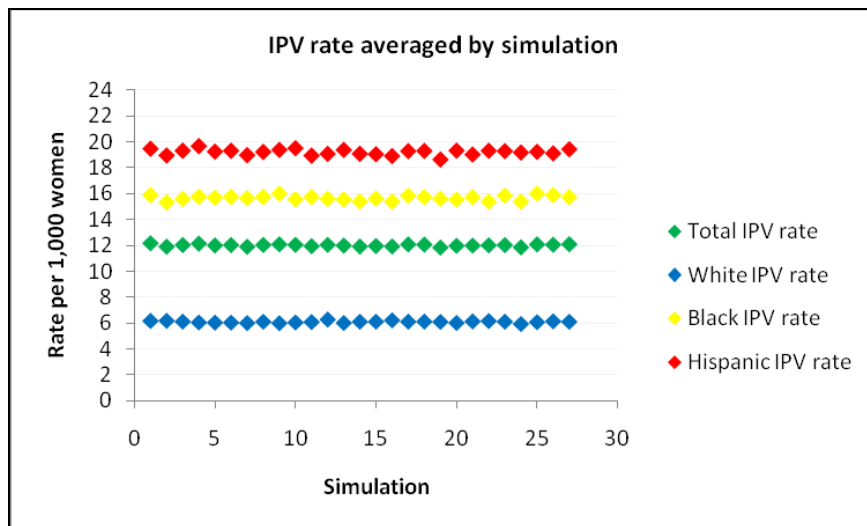
The results are both expected and unexpected. Thus, the lower number of police calls (interpreted as an “official” rate) relative to the reported incidents is in agreement with the literature (Wolf et al. 2003). According to the model, the reported incidents to the police are within a range of 16% – 25%. In the model, Black women appear to report to the police more often than Hispanic and White women which is in agreement with the literature (Catalano 2007)

The results by race and ethnicity differ from what is described in the literature as Hispanic women appear to have the highest IPV rate. According to the majority of studies, the rate of reported intimate partner violence is higher for Black women while White and Hispanic women do not significantly differ (Tjaden and Thoennes 2000). However, this difference is predictable since according to **Table 3**, almost twice as many Hispanic women are at or below poverty level compared with Black women. As I discussed in Chapter 4, the definition of a race has not been consistent in the literature and changing racial and ethnic categories in the model may alter the result. Furthermore, all simulations were based on only one set of Digital Population realizations

and in order to test the consistency of the results it will be necessary to create multiple realizations of Chicago's population and re-run the tests.

While I expected to see some differences in annual IPV rates at least between simulation number 1 and simulation number 27, which represent the extreme change in parameter values, **Figure 6** demonstrates a fairly steady trend. Some minor fluctuations in Black and Hispanic IPV rates may be explained by the uncertainty in the data and a small sample size. It thus appears that parameter changes did not have a visually noticeable effect on IPV rates on the level of a total population and population by race.

Figure 6. IPV Rate as Occurred in “Reality”



I will note that **Figure 7** shows relatively more noticeable fluctuations in results, which might also be due to some uncertainty or a small sample size. However, the goal of this research is not to analyze changing rates of police calls on the basis of policy changes. Police calls represent the “official” statistics to be compared with the “real” statistics on a population level.

Figure 7. IPV Rate as Occurred in “Police Reports”

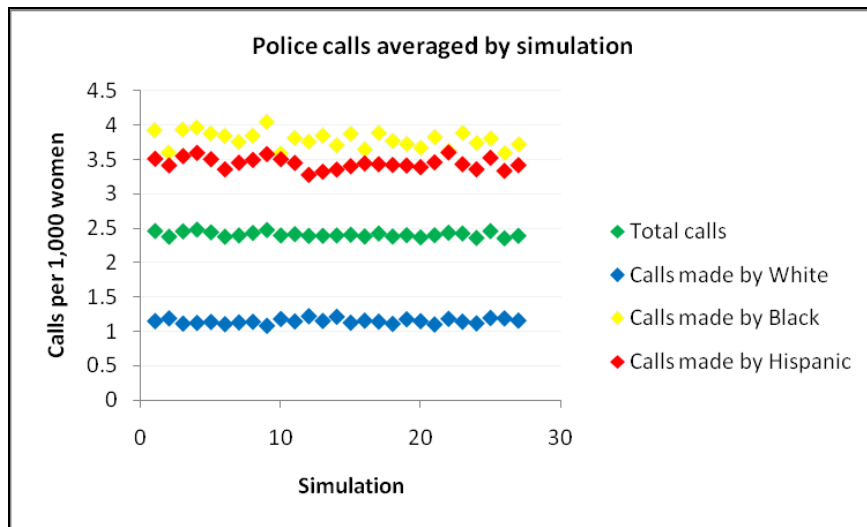


Table 4 reports mean, standard deviation and standard error by simulation and **Table 5** reports the slope and R^2 values for each of the regressions. It appears there is a great variability in the data and the correlation between the dependent and independent variables is weak. As I was running simulations in batches of 5 runs for each parameter change, every new addition of data changed the slope (occasionally, its sign as well) and lowered R^2 values.

Table 4. Mean, Standard Deviation and Standard Error by Experiment

Experiment	Beds	PA	CS	Total			White			Black			Hispanic		
				Mean	St. Dev.	St. Error	Mean	St. Dev.	St. Error	Mean	St. Dev.	St. Error	Mean	St. Dev.	St. Error
1	2	0	0	12.18	2.09	0.11	6.16	1.67	0.09	15.90	4.04	0.22	19.44	4.24	0.23
2	2	0	50	11.91	1.98	0.10	6.17	1.71	0.09	15.34	3.95	0.21	18.92	4.18	0.23
3	2	0	100	12.05	2.20	0.12	6.11	1.66	0.09	15.60	4.32	0.23	19.28	4.56	0.25
4	2	50	0	12.15	2.01	0.11	6.04	1.57	0.08	15.77	4.22	0.23	19.64	4.03	0.22
5	2	50	50	12.01	2.01	0.11	6.03	1.65	0.09	15.70	4.45	0.24	19.21	3.99	0.22
6	2	50	100	12.04	2.11	0.11	6.03	1.77	0.09	15.76	4.15	0.22	19.28	4.36	0.24
7	2	100	0	11.91	2.16	0.11	6.00	1.77	0.09	15.66	4.43	0.24	18.94	4.12	0.22
8	2	100	50	12.05	2.07	0.11	6.10	1.80	0.09	15.75	4.21	0.23	19.19	4.02	0.22
9	2	100	100	12.10	2.05	0.11	5.96	1.65	0.09	16.02	4.11	0.22	19.35	4.10	0.22
10	4	0	0	12.06	1.98	0.10	6.04	1.67	0.09	15.58	4.31	0.23	19.47	4.03	0.22
11	4	0	50	11.95	2.19	0.12	6.08	1.73	0.09	15.75	4.53	0.24	18.90	4.25	0.23
12	4	0	100	12.05	2.07	0.11	6.27	1.78	0.09	15.60	4.41	0.24	19.04	4.16	0.22
13	4	50	0	12.00	2.12	0.11	6.00	1.64	0.09	15.56	4.41	0.24	19.34	4.04	0.22
14	4	50	50	11.93	2.08	0.11	6.10	1.69	0.09	15.40	4.24	0.23	19.04	4.31	0.23
15	4	50	100	11.97	2.01	0.11	6.10	1.67	0.09	15.62	4.33	0.23	19.01	4.19	0.23
16	4	100	0	11.93	2.08	0.11	6.21	1.62	0.08	15.40	4.54	0.25	18.87	4.17	0.22
17	4	100	50	12.09	2.14	0.11	6.10	1.67	0.09	15.86	4.70	0.25	19.25	4.09	0.22
18	4	100	100	12.07	2.10	0.11	6.11	1.68	0.09	15.74	4.09	0.22	19.27	4.21	0.23
19	6	0	0	11.84	2.18	0.12	6.09	1.67	0.09	15.62	4.37	0.24	18.60	4.32	0.23
20	6	0	50	11.98	2.11	0.11	6.00	1.84	0.10	15.54	4.17	0.22	19.29	4.22	0.23
21	6	0	100	12.00	2.00	0.11	6.12	1.69	0.09	15.74	4.21	0.23	18.99	4.13	0.22
22	6	50	0	12.02	2.08	0.11	6.15	1.69	0.09	15.39	4.34	0.23	19.28	4.08	0.22

Table 4 (cont.)

Experiment	Beds	PA	CS	Total			White			Black			Hispanic		
				Mean	St. Dev.	St. Error	Mean	St. Dev.	St. Error	Mean	St. Dev.	St. Error	Mean	St. Dev.	St. Error
24	6	50	100	11.86	2.16	0.11	5.92	1.66	0.09	15.4	4.22	0.23	19.14	4.47	0.24
25	6	100	0	12.09	2.10	0.11	6.06	1.65	0.09	16.01	4.37	0.24	19.19	4.31	0.23
26	6	100	50	12.07	2.08	0.11	6.13	1.71	0.09	15.90	4.51	0.24	19.08	4.01	0.22
27	6	100	100	12.10	2.17	0.11	6.10	1.71	0.09	15.74	4.46	0.24	19.04	4.23	0.23

Table 5. Slope and R² values

Grouped by:	Scenario	Total		White		Black		Hispanic	
		Slope	R ²	Slope	R ²	Slope	R ²	Slope	R ²
Increased # of shelter beds	PA = 0	-0.085	0.0992	-0.0197	0.0052	-0.071	0.015	-0.2091	0.1033
	CS = 0								
	PA = 0	0.017	0.0048	-0.0426	0.0252	0.0505	0.0073	0.0942	0.0217
	CS = 50								
	PA = 0	-0.0118	0.0022	0.0031	0.0001	0.0335	0.0034	-0.0737	0.0119
	CS = 100								
	PA = 50	-0.0337	0.015	0.0279	0.0124	-0.0958	0.0232	-0.089	0.015
	CS = 0								
	PA = 50	0.0077	0.0013	0.0189	0.0055	0.0401	0.0041	0.0103	0.0004
	CS = 50								
	PA = 50	-0.0451	0.0241	-0.0284	0.011	-0.0909	0.0193	-0.0347	0.0035
	CS = 100								
	PA = 100	0.0465	0.035	0.0168	0.039	0.0878	0.0237	0.0641	0.0099
	CS = 0								
	PA = 100	0.005	0.0006	0.0095	0.0014	0.0378	0.0037	-0.0282	0.0026
	CS = 50								
	PA = 100	0.0016	4E-06	0.0296	0.0147	-0.07	0.0105	0.0125	0.0005
	CS = 100								
Increased CS	PA = 0	-0.0014	0.017	-0.0005	0.0026	-0.003	0.0226	-0.0015	0.0031
	beds = 2								
	PA = 0	-5E-05	3E-05	0.0024	0.0348	0.0003	0.0001	-0.0044	0.0368
	beds = 4								
	PA = 0	0.0016	0.0221	0.0004	0.0015	0.0012	0.0028	0.0039	0.0196
	beds = 6								
	PA = 50	-0.0011	0.0109	-0.0001	0.0001	-0.0001	2E-05	-0.0036	0.0198
	beds = 2								
	PA = 50	-0.0003	0.0011	0.001	0.0102	0.0007	0.0009	-0.0034	0.0171
	beds = 4								
	PA = 50	0.0004	0.0014	0.0015	0.0225	-0.0015	0.0043	-0.0001	2E-05
	beds = 6								
	PA = 100	0.0019	0.0325	-0.0001	0.0002	0.0036	0.0192	0.0041	0.0246
	beds = 2								
	PA = 100	0.0014	0.0249	-0.001	0.0116	0.0034	0.0189	0.004	0.0329
	beds = 4								
	PA = 100	0.0001	0.0001	0.0004	0.0012	-0.0027	0.0127	0.0021	0.0089
	beds = 6								
Increased PA	CS = 0	-0.0028	0.0648	-0.0017	0.024	-0.0024	0.0123	-0.005	0.029
	beds = 2								
	CS = 50	0.0013	0.0202	-0.0008	0.0053	0.0041	0.0288	0.0027	0.0135
	beds = 2								
	CS = 100	0.0005	0.002	-0.0013	0.0147	0.0042	0.0239	0.0007	0.0006
	beds = 2								
	CS = 0	-0.0013	0.0163	0.0017	0.0287	-0.0017	0.0052	-0.006	0.0538
	beds = 4								
	CS = 50	0.0014	0.0243	0.0003	0.0007	0.0011	0.0018	0.0035	0.0246
	beds = 4								
	CS = 100	0.0002	0.0004	-0.0016	0.0202	0.0014	0.0031	0.0023	0.0112
	beds = 4								
	CS = 0	0.0025	0.0536	-0.0002	0.0004	0.0039	0.025	0.0059	0.0528
	beds = 6								
	CS = 50	0.0009	0.0096	0.0013	0.0167	0.0036	0.0213	-0.0022	0.0089
	beds = 6								
	CS = 100	0.001	0.0078	-0.0002	0.0006	1E-05	2E-07	0.0041	0.0279
	beds = 6								

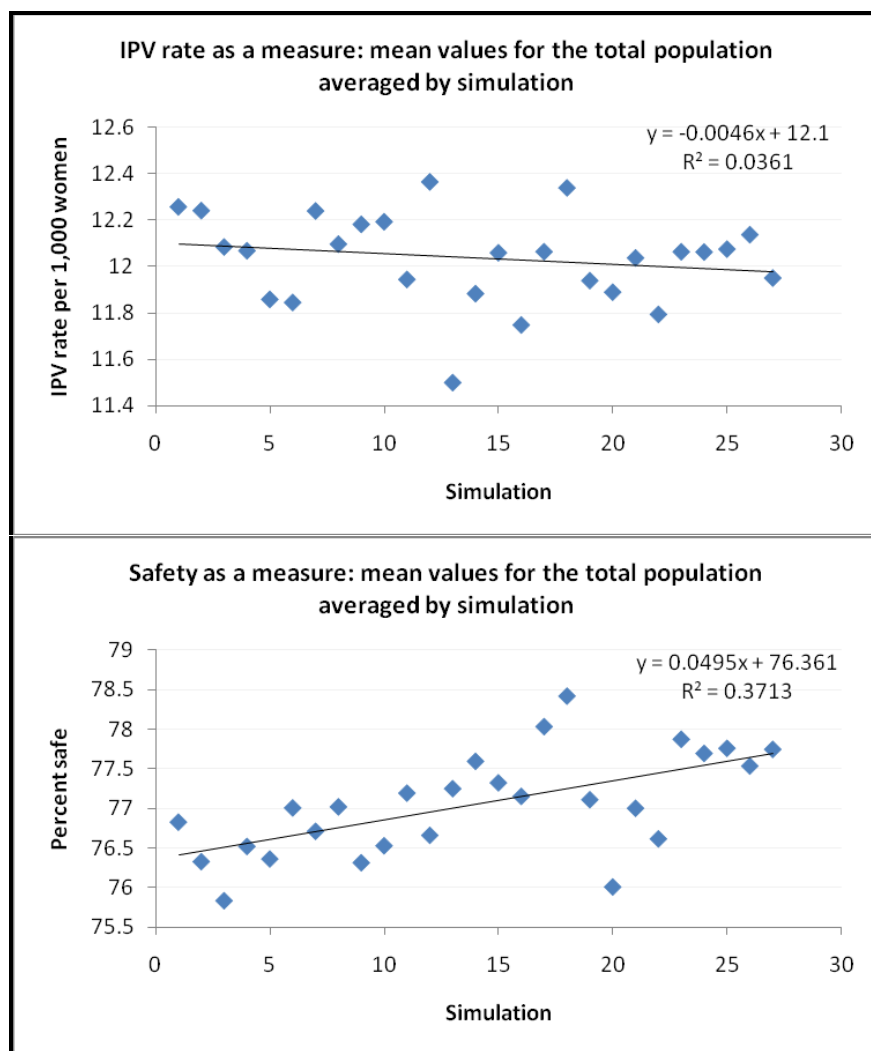
Due to so much variability in the results and the apparent lack of an appropriate number of simulation runs, it is difficult if not impossible to make any definitive conclusions regarding what impact the parameters of interest might have on intimate partner rates. Multiple simulations are a requirement for a model driven by stochastic processes. In my model, essentially every input is represented by a probability or a value with a standard deviation in order to represent uncertainty in making decisions. While this adds more reality to representing women's actions as well as more reality to representing the level of complexity of such problem as intimate partner violence, stochastic elements may not be helpful in unrevealing significant trends should they exist. In addition, it may be difficult to determine which parameters have a significant effect especially in the case of nonlinear relationships. Last but not least, the results might have been skewed by a small population sample.

Despite the lack of definitive trends for each scenario, it appears that different scenarios show a variability of trends for women of different races. This variability is likely to be preserved if more simulation runs are conducted. As such, the primary question of interest is why a given combination of parameters may potentially increase violence rates for one group and decrease violence rates for another group of women.

Considering that income plays one of the major roles in determining the risk for domestic violence it is necessary to analyze the results by both race and income. In addition, it may be necessary to employ a different measure of success of the system, namely what percentage of women who have been battered make it out of the system and become safe by the end of the simulation period. The primary reason for choosing an annual incident rate as a measuring variable was that it is the most widely employed measure used in the literature and it can thus be easily used to compare the real-world data to the model results. However, the percentage of

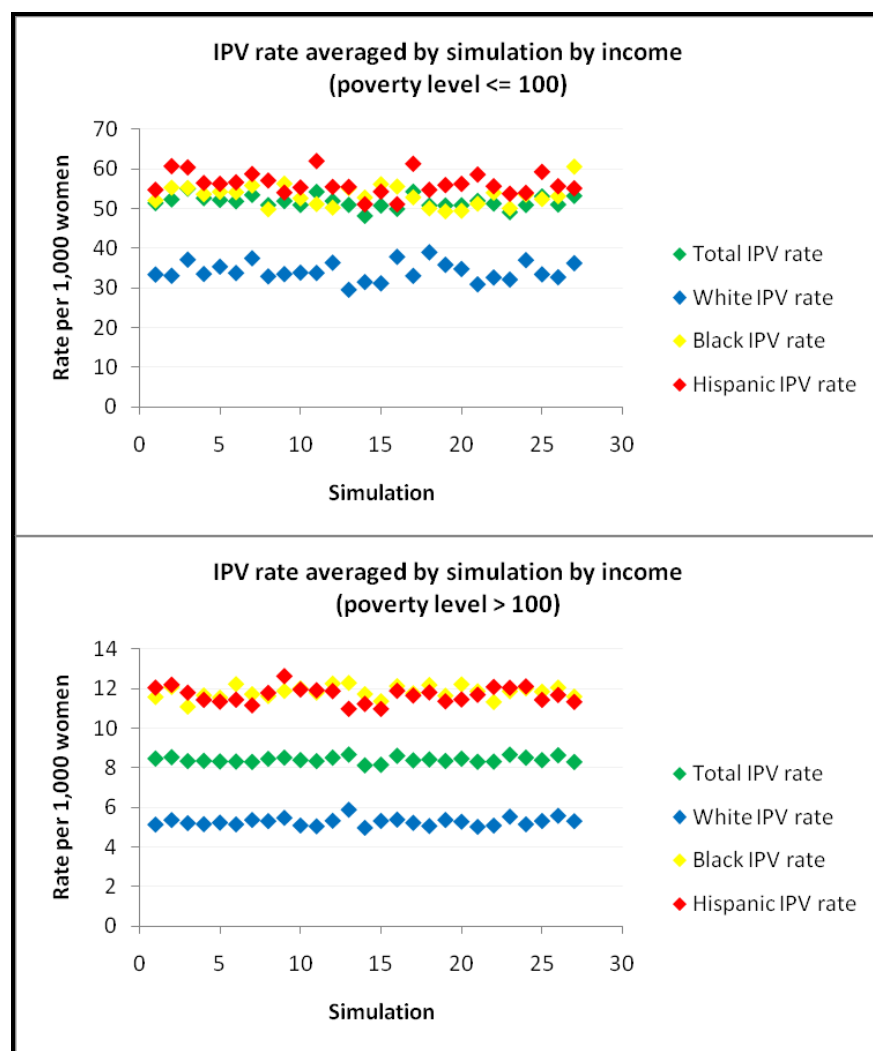
women who make it out of the model system may be a more direct and straightforward way to determine the success of the model system. For example, it may so happen that for a given scenario a higher percentage of women will leave the system but this change will not be reflected in the annual incident rates. Already, this consideration creates a potential problem for policy-makers to address: if the system appears to work and produce satisfactory results, why is the success not reflected in incident rates? **Figure 8** demonstrates the difference in R^2 values and in how strong the trends appear to be for two measuring parameters (both based on 5 runs).

Figure 8. IPV Rate and Safety as Measuring Parameters



The next two graphs are based on only 5 runs and hence can be used only for illustration of possible answers. Thus, **Figure 9** demonstrates that the intimate partner violence rate for women living at or under the poverty level is several times larger than the one of more affluent women. Once again, the rate for White women is lower than for Black and Hispanic women. It appears that the rate for Black and Hispanic women is approximately within the same range⁶.

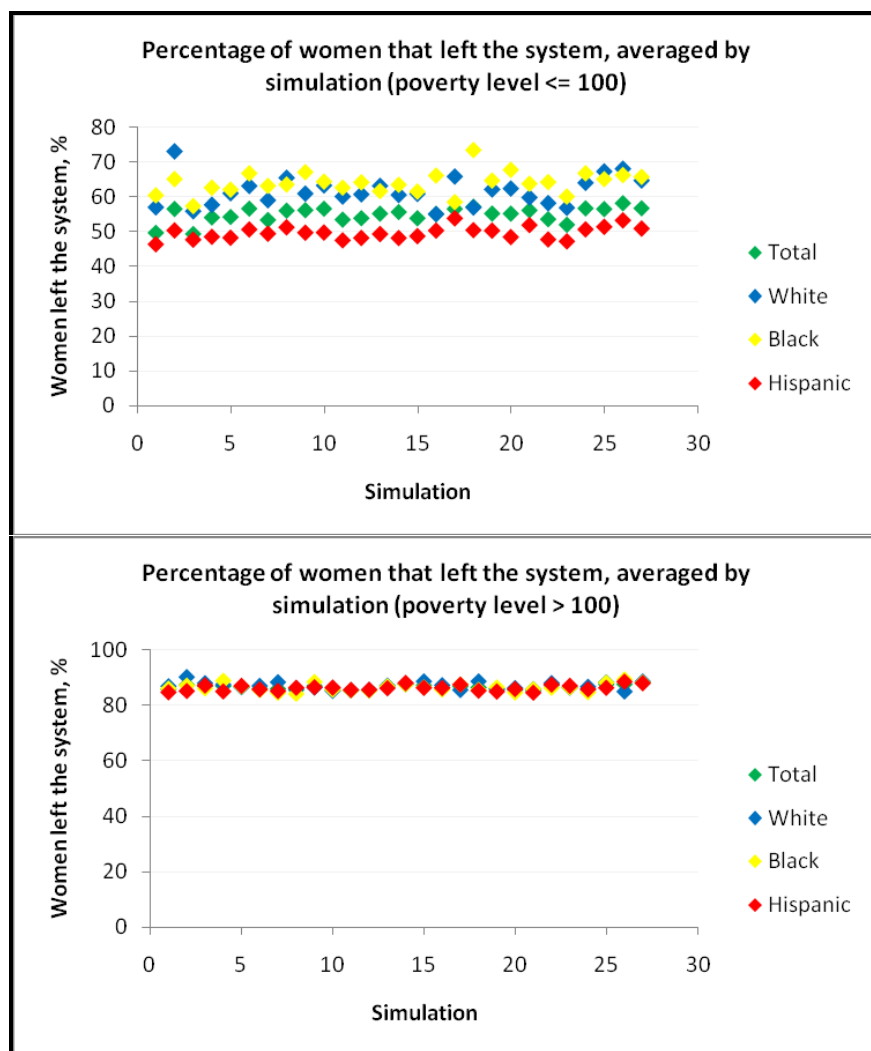
Figure 9. IPV Rate by Income Level



⁶ These results refer to the “real” incidents. I have not recorded the percentage of police calls for women of different income levels

Figure 10 is based on 10 runs and indicates that income level determines the level of success. Thus, the percentage of women who left the system and whose poverty level is above 100% is in a range of 80-85% regardless their race. On the other hand, there appear to be differences by race for those at or under the poverty level. Thus, Black and White women have approximately the same rates of success while the percentage of Hispanic women who left the system appears to be about 10 points lower. It is doubtful that this ratio will change significantly if more runs are made.

Figure 10. Safety by Income Level



It is thus important to realize that women from various socio-economic and racial groups have very different levels of exposure to violence and the ability of low-income women to leave the system appears to be substantially lower. One of the possible explanations for the behavior of the model is that a higher percentage of more affluent women who experience relatively little violence leave the system while a greater percentage of those under the poverty level and at a greater risk of violence, stay in the system. In other words, those who contribute little to the total violence rate, leave and those who contribute a lot – stay.

Why is this happening? I previously suggested that an increased public awareness should increase the probability of leaving the relationship though low-income women may not benefit as they will be likely to return to their abuser. Yet there is a possibility that with increased public awareness, more women with higher income will leave the relationship and enter the shelters (the model does not distinguish by income level who enters the shelter; everyone is allowed in). At the same time, women with lower income either do not leave the relationship or if they leave they have to compete for shelter space. Since shelters pick their future residents at random, low-income women may have a lower chance of being selected if they are underrepresented in the total population of those requesting shelter beds. For this reason, increased number of shelter beds may not show any patterns as shelters simply do not end working with an actual population in need.

Of course, it all may be a matter of the number of shelter beds. After all, a shelter is only a temporary solution both in real life and in the model. Specifically in the model, a shelter serves as a temporary holder for a given number of time-steps during which a shelter resident is considered safe. As such, it is possible that the system will demonstrate stronger trends if there

are many to unlimited shelter beds available. However, without additional support related to housing, employment and education, low-income women will simply cycle between shelters until the end of the simulation time and will remain safe via this unrealistic option.

As I first suggested, increased cultural sensitivity is expected to have a diminishing effect on the rates of violence among White and Black women as they should have a higher probability of visiting, while it is not expected to have any impact on probability of visiting of Hispanic women. Yet it is possible that as more White and Black women start requesting and receiving shelter beds, a lower percentage of Hispanic women will enter shelters due to a limited shelter space. As according to the model, Hispanic women are exposed to violence at a greater degree, increased cultural sensitivity may actually *increase* total violence rates since the population most at risk has less access to safety space due to competition with other groups.

Finally, the location is important. If the shelter's location is not convenient relative to the areas where the majority of population at need resides, at some point higher number of shelter beds as well as higher public awareness or cultural sensitivity may stop showing any effect as women will have a low probability of visiting. As I previously discussed, I had to make a decision regarding how many shelters to keep in the model and whether to keep their location constant while varying the number of beds. Due to time limitations, I have not explicitly measured the rate of violence by census tract in order to test the effectiveness of shelter locations. However, this is one of the questions that need to be answered: is it more effective to have one big shelter with many beds or to have many small shelters spread out? And how is shelter location going to affect the probability of visiting of women from different socio-economic groups? Confusing trends (negative or positive) of increasing number of shelter beds coupled with changes in public awareness and cultural sensitivity may be a reflection of some

actions of women trying to get into a shelter. Thus, if more low-income women made it to a shelter the trend may show a negative effect while it may show a positive effect if more affluent women occupied the majority of beds (current version of the model assumes there is an equal probability of women of either income level to go to a shelter).

On the technical side, 1% population sample is likely to be too small in order to fully capture the effects of the tested parameters. It is possible that a larger sample will exhibit less dispersion in data and will thus require fewer simulation runs. Unfortunately, this would require significant computational resources.

5.4 Conclusion

Due to a number of limitations it was not possible to make definitive inferences regarding how public awareness, cultural sensitivity and a number of shelter beds affects domestic violence rates. However, the system shows that there is variability in whether these parameters have a positive or negative effect on IPV rates for women from different socio-economic and racial groups. I offered a number of explanations of why this might be happening. Additionally, I suggested that a different measuring parameter of success of the system should be used.

Chapter 6: Conclusion

In this chapter I summarize the results as well as the limitations of this study. I also discuss the usefulness of agent-based modeling approach to understanding the dynamics of intimate partner violence as well as understanding how women with different socio-cultural and economic background have differential responses to policy changes. I conclude the chapter with recommendations for future research.

6.1 Conclusions

I have developed an agent-based model attempting to understand the dynamics of intimate partner violence in the lives of women who come from a variety of backgrounds and therefore do not respond equally to a one-size-fit-all set of remedies to violence at home. To the best of my knowledge, this is the first project that attempts to evaluate the effectiveness of formal and informal support systems in relation to intimate partner violence. While conducting an extensive literature review in preparation for the work, I have only come across a few studies that used GIS to analyze a spatial element in relation to domestic violence. However, all of the research of this kind appears to be in the field of criminology (Meeker 2005; Fagan and Wilt 2003). For example, Goodman, Meeker and Plyer (2005) used GIS to investigate the relationship between domestic violence and legal system (police calls, legal aid locations, and restraining orders) and looked at patterns from the point of view of social disorder theory. In a similar way, Valenzuela et al (2005) did a hot spot analysis of domestic violence calls for service in relation to the location of Legal Aid offices. Ranjan and Raghavan (2008) had a similar approach and found clusters of IPV in high poverty neighborhoods. In fact, the 2008 annual American Society of

Criminology conference had a whole session devoted to spatial analysis related to intimate partner violence and rape.

To the best of my knowledge, this is one of the few projects that attempt to create a dynamic model of IPV. Pollak (2004) undertook a different approach and created an intergenerational model of domestic violence. Farmer and Tiefenthaler (1996) developed a model from an economic perspective and suggested that many battered women use services as a way to threat to leave the relationship; the authors operate under the assumption that the threat to leave decreases the risk of violence. A roundtable titled *Asking Better Questions: Modeling Domestic Violence as a Dynamic Process* (held by American Society of Criminology meeting in 1999) appears to be the closest attempt to create a dynamic model of intimate partner violence while taking more than one factor into account. This model considers such things as personal attitudes, cultural beliefs, the gap between the ideal and the real world, fear and intimidation and it appears to place more emphasis on psychological factors and the assumption that domestic violence is a part of psychological problems. To the best of my knowledge, this model has never been moved beyond the conceptual stage of the development. None of these studies are based on any empirical data reported in the literature.

As such, I demonstrated here a new method of understanding the dynamics of IPV. In addition to incorporating a spatial element, I attempted to include as much heterogeneity into women's decisions as possible on the basis of their race and ethnicity. At the current stage of research, I was not able to make definitive conclusions regarding what set of parameters decrease or increase violence rates yet it appears that there is much variability in how women of different groups responded to the change in parameters. On a general level, the model demonstrated the

differences in IPV rates between women on different races/ethnicity as reported by police and as those that happened in reality.

Agent-based modeling approach is especially useful as it allows me to capture as much heterogeneity as needed for the purposes of the research. It thus demonstrates that even if the policy is supposed to create a positive effect it may in fact end up creating a negative effect since different populations will respond to it differently. Furthermore, it is useful due to ethical and time and money considerations. Testing policies on people being already in a risky environment may put them at even greater risk of violence. Furthermore, it often takes time for the policy to take effect. As I previously discussed, leaving the violent relationship is a long, cyclical process that often takes years. As such, agent-based models can be used as a virtual lab where the cost of the research is relatively cheap and no subjects will die or be injured during the experiments.

6.2 Limitations

This model is a somewhat generalized template that opens up a lot of room for further research and improvement. On a conceptual basis, the study would have benefited if additional subject matter expert opinions. It could have specifically benefited from the opinion of experts specializing in Chicago area. At its current stage, the model can be used to provide a qualitative insight into the problem of domestic violence. In order for the model to be valid on a quantitative level it needs a better representation of Chicago's social support system and it needs to be calibrated with police records. As I previously noted, calibration, validation and verification of social models is a significant challenge. In addition, the behavior of the model can also be influenced by how intimate partner violence and race and ethnicity are defined.

A lot of uncertainty represented in the model is useful as it demonstrates the uncertain nature of the problem of intimate partner violence itself. Quantitatively, uncertainty may pose limits to using the model for future forecasts. Yet one of the purposes of the model is to demonstrate and explore the relations in the system. As such, it can help develop other mental models or enhance the existing ones.

6.3 Future Research

I have already outlined some of the future research in Chapter 5. Thus, a different measure of success of the system may be more useful as well as tracking in details how women from different background respond to changes in the parameters. For example, I did not measure the impact of parameters on the rate of serious injuries while those appear to be more significantly related to the change in income (according to Salari and Baldwin 2002).

On a technical side, the model needs a better representation of Chicago support system. For example, it will be beneficial to represent the service system in terms of their carrying capacity. It is also necessary to account for single, divorced and separated women as they experience more IPV than married women (Brownridge 2009). Furthermore, an informal support network may be defined on the basis of racial and socio-economic characteristics. It may be beneficial to expand on the informational aspect of help-searching behavior and to allow human agents to pass on and “forget” information about services with time (currently the model assumes a perfect information environment). For immigrant communities, it may be important to estimate the rate of acculturation and its influence on rate of IPV. The formal support network (shelters and community centers) can also be expanded to include other possible services (e.g., health clinics or workforce development programs) and the behavior of each service agent can be represented

by more detailed rules (e.g., a woman must satisfy specific requirements to be accepted into a workforce program or an immigrant woman may not be accepted into a shelter if the staff does not speak her language). The access to services can be modeled by taking road network and transportation modes into account.

REFERENCES

- Illinois coalition of domestic violence: Report*. 2008. ICADV.
- Abraham, Margaret. 2000. Isolation as a form of marital violence: The South Asian immigrant experience. *Journal of Social Distress and the Homeless* 9 (3): 221-36.
- Abu-Ras, Wahiba. 2007. Cultural beliefs and service utilization by battered Arab immigrant women. *Violence Against Women* 13 (10): 1002-28.
- Ahmad, Farah, Sarah Riaz, Paula Barata, and Donna E. Stewart. 2004. Patriarchal beliefs and perceptions of abuse among South Asian immigrant women. *Violence Against Women* 10 (3): 262-82.
- Akers, Caroline, and Catherine Kaukinen. 2009. The police reporting behavior of intimate partner violence victims. *Journal of Family Violence* 24: 159-71.
- Aldarondo, Etiony, Glenda Kaufman Kantor, and Jana Jasinski. 2002. A risk marker analysis of wife assault in Latino families. *Violence Against Women* 8 (4): 429-54.
- Allen, Nicole E., Deborah I. Bybee, and Cris M. Sullivan. 2004. Battered women's multitude of needs: Evidence supporting the needs for comprehensive advocacy. *Violence Against Women* 10 (9): 1015-35.
- Apsler, Robert, Michele R. Cummins, and Steven Carl. 2003. Perceptions of the police by female victims of domestic partner violence. *Violence Against Women* 9 (11): 1318-35.
- Avakame, Edem M., and James J. Fyfe. 2001. Differential police treatment of male-on-female spousal violence: Additional evidence on the leniency thesis. *Violence Against Women* 7 (1): 22-45.
- Axelrod, Robert. 2005. Agent-based modeling as a bridge between disciplines. In *Handbook of computational economics, vol. 2: Agent-based computational economics.*, eds. Kenneth L. Judd, Leigh Tesfatsion. Vol. 2. North-Holland.
- Axtell, Robert. 2000. Why agents? On the varied motivations for agent computing in the social sciences. *Center on Social and Economic Dynamics, Working Paper no. 17*.
- Baker, Charlene K., Sarah L. Cook, and Fran H. Norris. 2003. Domestic violence and housing problems: A contextual analysis of women's help-seeking, received informal support, and formal system response. *Violence Against Women* 9 (7): 754-83.
- Bassuk, Ellen L., Jennifer N. Perloff, and Ree Dawson. 2001. Multiply homeless families: The insidious impact of violence. *Housing Policy Debate* 12 (2): 299-320.

- Basu, Bharati, and Felix Famoye. 2004. Domestic violence against women, and their economic dependence: A count data analysis. *Review of Political Economy* 16 (4): 457-72.
- Beeble, Marisa L., Lori A. Post, Deborah Bybee, and Cris M. Sullivan. 2008. Factors related to willingness to help survivors of intimate partner violence. *Journal of Interpersonal Violence* 23 (12): 1713-29.
- Bell, Holly. 2003. Cycles within cycles: Domestic violence, welfare, and low-wage work. *Violence Against Women* 9 (10): 1245-62.
- Benson, Sarah. 2009. Failure to arrest: A pilot study of police response to domestic violence in rural Illinois. *American University Journal of Gender, Social Policy and the Law* 17, Summer 2009 (Illinois Public Law Research Paper No. 08-07).
- Block, Carolyn Rebecca. 2000. *The Chicago women's health risk study: Risk of serious injury or death in intimate violence: A collaborative research project*. Washington DC: United States Department of Justice, National Institute of Justice, NCJ 184511.
- Blumenberg, Evelyn. 2002. On the way to work: Welfare participants and barriers to employment. *Economic Development Quarterly* 16 (4): 314-25.
- Bohn, Lauren. 2009. Chicago abuse shelter a rarity serving Muslim women. *Medill Reports Chicago*. Available from <http://news.medill.northwestern.edu/chicago/news.aspx?id=143635>.
- Bonabeau, Eric. 2002. Agent-based modeling: Methods and techniques for simulating human systems. *PNAS* 99 (3): 7280-7287.
- Bosch, Kathy, and Walter R. Schumm. 2004. Accessibility to resources: Helping rural women in abusive partner relationships become free from abuse. *Journal of Sex and Marital Therapy* 30 (5): 357-70.
- Brabeck, Kalina M., and Michele R. Guzmán. 2008. Frequency and perceived effectiveness of strategies to survive abuse employed by battered Mexican-origin women. *Violence Against Women* 14 (11): 1274-94.
- Brown, Laurie, and Ann Harding. 2002. Social modelling and public policy: Application of microsimulation modelling in Australia. *Journal of Artificial Societies and Social Simulation* 5 (4). Available from <http://jasss.soc.surrey.ac.uk/5/4/6.html>.
- Browne, Angle, Any Salomon, and Shari S. Bassuk. 1999. The impact of recent partner violence on poor women's capacity to maintain work. *Violence Against Women* 5 (4): 393-426.
- Brownridge, Douglas A. 2009. *Violence against women: Vulnerable populations*. New York: Routledge.

- Bui, Hoan N. 2003. Help-seeking behavior among abused immigrant women: A case of Vietnamese American women. *Violence Against Women* 9 (2): 207-39.
- Bui, Hoan N., and Merry Morash. 1999. Domestic violence in the Vietnamese immigrant community: An exploratory study. *Violence Against Women* 5 (7): 769-95.
- Carlson, Bonnie E., Louise-Anne McNutt, Deborah Y. Choi, and Isabel M. Rose. 2002. Intimate partner violence and mental health: The role of social support and other protective factors. *Violence Against Women* 8 (6): 720-45.
- Carlson, Bonnie E., and Alissa Pollitz Worden. 2005. Attitudes and beliefs about domestic violence: Results of a public opinion survey: I. definitions of domestic violence, criminal domestic violence, and prevalence. *Journal of Interpersonal Violence* 20: 1197-218.
- Carroll, Joseph. Americans satisfied with number of friends, closeness of friendships. in Gallup News Service [database online]. 2004. Available from <http://www.gallup.com.proxy2.library.uiuc.edu/poll/10891/americans-satisfied-number-friends-closeness-friendships.aspx>.
- Castle, Christian, and Andrew Crooks. 2006. Principles and concepts of agent-based modelling for developing geospatial applications. *UCL Working Papers Series no. 110*.
- Catalano, Shannan. 2007. *Intimate partner violence in the United States*. Washington DC: U.S. Department of Justice, Bureau of Justice Statistics, NCJ 210675.
- Chabot, Heather Frasier, Tracy L. Tracy, Christine A. Manning, and Chelsea A. Poisson. 2009. Sex, attribution, and severity influence intervention decisions of informal helpers in domestic violence. *Journal of Interpersonal Violence* 24 (10): 1696-713.
- Cole, Patricia R. 2001. Impoverished women in violent relationships: Designing services to fit their reality. *Violence Against Women* 7 (2): 222-33.
- Coulter, Martha. 2004. *The impact of domestic violence on the employment of women on welfare*. Washington DC: U.S. Department of Justice, National Institute of Justice, NCJ 205294.
- Crenshaw, K. 1997. Mapping the margins: Intersectionality, identity politics, and violence against women of color. In *The legal response to violence against women*, ed. K.J. Maschke, 91-149, New York: Garland Publishing, Inc.
- Crowell, Nancy A., and Ann W. Burgess, eds. 1996. *Understanding violence against women*. Washington DC: National Academy Press.
- Cunradi, Carol B., Raul Caetano, and John Schafer. 2002. Socioeconomic predictors of intimate partner violence among White, Black, and Hispanic couples in the United States. *Journal of Family Violence* 17 (4): 377-89.

- Dasgupta, Shamita Das. 2000. Charting the course: An overview of domestic violence in the South Asian community in the United States. *Journal of Social Distress and the Homeless* 9 (3): 173-85.
- de Smith, Michael J., Michael F. Goodchild, and Paul A. Longley. 2009. *Geospatial analysis: A comprehensive guide to principles, techniques, and software tools*. 3rd ed. Leicester: Matador.
- Donnelly, Denise, Kimberly Cook, Debra van Ausdale, and Lara Foley. 2005. White privilege, color blindness, and services to battered women. *Violence Against Women* 11 (1): 6-37.
- Donnelly, Denise, Kimberly Cook, and Linda Wilson. 1999. Provision and exclusion: The dual face of services to battered women in three Deep South states. *Violence Against Women* 5 (7): 710-41.
- Dutton, Mary Ann, Leslye E. Orloff, and Giselle Aguilar Hass. 2000. Characteristics of help-seeking behaviors, resources and service needs of battered immigrant Latinas: Legal and policy implications. *Georgetown Journal on Poverty Law & Policy* 9 (2): 245-306.
- Ehlschlaeger, Charles. R. "Digital Populations: Building Multiple Realizations of Population for Cluster Detection Analysis. Accepted for Presentation at GIScience2004 Conference, College Park Campus, Maryland, USA, October 20, 2004. Available from <http://chuck.Ehlschlaeger.info/2004/giscience2004>.
- Fagan, J., J. Medina-Ariza, and S. A. Wilt. 2003. Social and ecological risks of domestic and non-domestic violence against women in New York City. Abstract. Available from <http://gis.columbia.edu/abstracts/fagan8.html>.
- Farmer, Amy, and Jill Tiefenthaler. 1997. An economic analysis of domestic violence. *Review of Social Economy* 55 (3): 337-58.
- Farmer, Amy, and Jill Tiefenthaler. 1996. Domestic violence: The value of services as signals. *The American Economic Review* 86 (2): 274-9.
- Felson, Richard B., Jeffery M. Ackerman, and Catherine Gallagher. 2005. *Police intervention and the repeat of domestic assault*. Washington DC: U.S. Department of Justice, National Institute of Justice, NCJ 210301.
- Felson, Richard B., Steven F. Messner, Anthony W. Hoskin, and Glenn Deane. 2002. Reasons for reporting and not reporting domestic violence to the police. *Criminology* 40 (3): 617-48.
- Felson, Richard B., and Paul-Philippe Paré. 2005. *The reporting of domestic violence and sexual assault by nonstrangers to the police*. Washington DC: U.S. Department of Justice, National Institute of Justice, NCJ 209039.

- Firestone, Juanita, Richard J. Harris, and William A. Vega. 2003. The impact of gender role ideology, male expectancies, and acculturation on wife abuse. *International Journal of Law and Psychiatry* 26: 549-64.
- Firestone, Juanita, Linda Lambert, and William Vega. 1999. Intimate violence among women of Mexican origin: Correlates of abuse. *Journal of Gender, Culture, and Health* 4 (2): 119-34.
- Fleury, Ruth E. 2002. Missing voices: Patterns of battered women's satisfaction with the criminal legal system. *Violence Against Women* 8 (2): 181-205.
- Fowler, Dawnovise N., and Hope M. Hill. 2004. Social support and spirituality as culturally relevant factors in coping among African American women survivors of partner abuse. *Violence Against Women* 10 (11): 1267-82.
- Fox, Greer, Michael Benson, Alfred DeMaris, and Judy Van Wyk. 2002. Economic distress and intimate violence: Testing family stress and resources theories. *Journal of Marriage and Family* 64: 793-807.
- Frias, Sonia, and Ronald Angel. 2005. The risk of partner violence among low-income Hispanic subgroups. *Journal of Marriage and Family* 67: 552-64.
- Fugate, Michelle, Leslie Landis, Kim Riordan, Sara Naureckas, and Barbara Engel. 2005. Barriers to domestic violence help seeking: Implications for intervention. *Violence Against Women* 11 (3): 290-310.
- Ganatra, Nimish. 2001. The cultural dynamic in domestic violence: Understanding the additional burdens battered immigrant women of color face in the United States. *Journal of Law in Society* 2: 109-47.
- Garcia, Lorena, Eric Hurwitz, and Jess Kraus. 2005. Acculturation and reported intimate partner violence among Latinas in Los Angeles. *Journal of Interpersonal Violence* 20 (5): 569-90.
- Gelles, Richard. 1980. Violence in the family: A review of research in the seventies. *Journal of Marriage and Family* 42 (4): 873-85.
- Gelles, Richard, and Jon Conte. 1990. Domestic violence and sexual abuse of children: A review of research in the eighties. *Journal of Marriage and Family* 52 (4): 1045-58.
- George, Christine, Susan Grossman, Marta Lundy, Cesraea Rumpf, and Sonya Crabtree-Nelson. 2010. *Analysis of shelter utilization by victims of domestic violence: Quantitative analysis*. Illinois Criminal Justice Information Authority, Grant # 06-DB-BX-0043.
- Gilbert, Nigel, and Pietro Terna. 2000. How to build and use agent-based models in social science. *Mind and Society* 1 (1): 57-72.

- Gillum, Tameka L. 2009. Improving services to African American survivors of IPV: From the voices of recipients of culturally specific services. *Violence Against Women* 15 (1): 57-80.
- Glass, Nancy, Nancy Perrin, Jacquelyn C. Campbel, and Karen Soeken. 2007. The protective role of tangible support on post-traumatic stress disorder symptoms in urban women survivors of violence. *Research in Nursing and Health* 30: 558-68.
- Goode, William. 1971. Force and violence in the family. *Journal of Marriage and Family* 33 (4): 624-36.
- Goodman, Lisa, Mary Ann Dutton, Natalie Vankos, and Kevin Weinfurt. 2005. Women's resources and use of strategies as risk and protective factors for reabuse over time. *Violence Against Women* 11 (3): 311-36.
- Goodman, Philip, James Meeker, and Michelle Plyer. 2005. Domestic violence: A multi-agency perspective. Abstract. *Paper presented at the annual meeting of the American Society of Criminology, Royal York, Toronto*. Available from http://www.allacademic.com/meta/p33901_index.html.
- Grant, B. F., D. A. Dawson, F. S. Stinson, S. P. Chou, M. C. Dufour, and R. P. Pickering. 2004. The 12-month prevalence and trends in DSM-IV alcohol abuse and dependence: United states, 1991–1992 and 2001–2002. *Drug and Alcohol Dependence* 74 (3): 223-34.
- Griffing, Sascha, Deborah Fish Ragin, Robert E. Sage, Lorraine Madry, Lewis Bingham E., and Beny J. Primm. 2002. Domestic violence survivors' self-identified reasons for returning to abusive relationships. *Journal of Interpersonal Violence* 17 (3): 306-19.
- Griffith, Sandy-Ann M., Charles Negy, and Derek Chadee. 2006. Trinidadian and U.S. citizens' attitudes toward domestic violence and their willingness to intervene: Does culture make a difference? *Journal of Cross-Cultural Psychology* 37 (6): 761-78.
- Grossman, Susan F., and Marta Lundy. 2007. Domestic violence across race and ethnicity: Implications for social work practice and policy. *Violence Against Women* 13 (10): 1029-52.
- Grzywacz, Joseph G., Pamela Rao, Amanda Gentry, Antonio Marín, and Thomas A. Arcury. 2009. Acculturation and conflict in Mexican immigrants' intimate partnerships: The role of women's labor force participation. *Violence Against Women* 15 (10): 1194-212.
- Hadeed, Linda F., and Nabila El-Bassel. 2006. Social support among Afro-Trinidadian women experiencing intimate partner violence. *Violence Against Women* 12 (8): 740-60.
- Hampton, Robert, William Oliver, and Lucia Magarian. 2003. Domestic violence in the African American community: An analysis of social and structural factors. *Violence Against Women* 9 (5): 533-57.

- Harris, Roma, Judy Stickney, Carolyn Grasley, Gail Hutchinson, Lorraine Greaves, and Terry Boyd. 2001. Searching for help and information: Abused women speak out. *Library & Information Science Research* 23: 123-41.
- Harway, Michele, and James M. O'Neil, eds. 1999. *What causes men's violence against women?* Thousand Oaks, CA: Sage
- Hattery, Angela J. 2009. *Intimate partner violence*. Lanham: Rowman & Littlefield Publishers, Inc.
- Hazen, Andrea, and Fernando I. Soriano. 2005. *Experience of intimate partner violence among U.S. born, immigrant and migrant Latinas*. Washington DC: U.S. Department of Justice, National Institute of Justice, NCJ 211509.
- Hilbert, Judith, Raiza Kolia, and Dawn VanLeeuwen. 1997. Abused women in New Mexican shelters: Factors that influence independence on discharge. *Affilia* 12 (4): 391-407.
- Hiselman, Jennifer. 1999. Intimate partner violence in Illinois. *Illinois Criminal Justice Information Authority: Trends and Issues Update* 1(8).
- Honeycutt, Todd C., Linda L. Marshall, and Rebecca Weston. 2001. Toward ethnically specific models of employment, public assistance, and victimization. *Violence Against Women* 7 (2): 126-40.
- Huang, Chien Ju, and Tiffany Gunn. 2001. An examination of domestic violence in an African American community in North Carolina: Causes and consequences. *Journal of Black Studies* 31 (6): 790-811.
- Iacono, Michael, Kevin Krizek, and Ahmed El-Geneidy. 2008. *Access to destination: How close is close enough? Estimating accurate distance decay functions for multiple modes and different purposes*. St. Paul, Minnesota: Minnesota Department of Transportation, MN/RC 2008-11.
- Ingram, Eben. 2007. A comparison of help seeking between Latino and non-Latino victims of intimate partner violence. *Violence Against Women* 13 (2): 159-71.
- Johnson, Ida. 2007. Victims' perceptions of police response to domestic violence incidents. *Journal of Criminal Justice* 35: 498-510.
- Johnson, Michael, and Kathleen Ferraro. 2000. Research on domestic violence in the 1990s: Making distinctions. *Journal of Marriage and Family* 62: 948-63.
- Kaci, Judy Hails. 1994. Aftermath of seeking domestic violence protective orders: The victim's perspective. *Journal of Contemporary Criminal Justice* 10 (3): 204-19.

- Kaukinen, Catherine. 2002. The help-seeking decisions of violent crime victims: An examination of the direct and conditional effects of gender and the victim-offender relationship. *Journal of Interpersonal Violence* 17 (4): 432-56.
- Kim, Jae Yop, and Kyu-taik Sung. 2000. Conjugal violence in Korean American families: A residue of the cultural tradition. *Journal of Family Violence* 15 (4): 331-45.
- Kim-Goh, Mikyong, and Jon Baello. 2008. Attitudes toward domestic violence in Korean and Vietnamese immigrant communities: Implications for human services. *Journal of Family Violence* 23: 647-54.
- Kurz, Demie. 1989. Social science perspectives on wife abuse: Current debates and future directions. *Gender and Society* 3 (4): 489-505.
- Landis, Leslie. 2007. *Assessment of the current response to domestic violence in Chicago*. City of Chicago Mayor's Office on Domestic Violence. Available from http://www.cityofchicago.org/content/dam/city/depts/fss/supp_info/DV/assessmentDVinchicago.pdf.
- Lee, Eunju. 2007. Domestic violence and risk factors among Korean immigrant women in the United States. *Journal of Family Violence* 22: 141-9.
- Lee, Roberta K., Vetta L. Sanders Thompson, and Mindy B. Mechanic. 2002. Intimate partner violence and women of color: A call for innovations. *American Journal of Public Health* 92 (4): 530-4.
- Levin, Rebekah, Lise McKean, and Jody Raphell. 2004. *Pathways to and from homelessness: Women and children in Chicago shelters*. Center of Impact Research. Available from www.chicagohomeless.org/files/images/homelessnessreport.pdf.
- Lichtenstein, Bronwen, and Ida Johnson. 2009. Older African American women and barriers to reporting domestic violence to law enforcement in the rural Deep South. *Women and Criminal Justice* 19 (4): 286-305.
- Lipsky, Sherry, Raul Caetano, Craig A. Field, and Gregory L. Larkin. 2006. The role of intimate partner violence, race, and ethnicity in help-seeking behaviors. *Ethnicity and Health* 11 (1): 81-100.
- Logan, T. K., Erin Stevenson, Lucy Evans, and Carl Leukefeld. 2004. Rural and urban women's perceptions of barriers to health, mental health, and criminal justice services: Implications for victim services. *Violence and Victims* 19 (1): 37-62.
- Loue, Sana. 2001. *Intimate partner violence: Societal, medical, legal and individual responses*. New York: Kluwer Academic/Plenum Publishers.

- Louie, Marcus, and Kathleen Carley. 2008. Balancing the criticisms: Validating multi-agent models of social systems. *Simulation Modelling Practice and Theory* 16: 242-56.
- Lyon, Eleanor, Shannon Lane, and Anne Menard. 2008. *Meeting survivors' needs: A multi-state study of domestic violence shelter experiences, final report*. Washington DC: U.S. Department of Justice, National Institute of Justice, NCJ 225025.
- Macal, Charles, and Michael North. 2009. Tutorial on agent-based modeling and simulation. Paper presented at Proceedings of the 2009 Winter Simulation Conference.
- Magen, Randy H., and Darryl S. Wood. 2006. *Intimate partner violence against AHTNA (Alaska Native) women in the Copper River Basin*. Washington DC: U.S. Department of Justice, National Institute of Justice, NCJ 215350.
- Meeker, James. 2005. *Utilizing GIS to study legal needs issues: An analysis of the LSC OIG Southern California mapping project*. Legal Services Corporation Office of Inspector General. Available from <https://www.oig.lsc.gov/mapping/mapping.htm>.
- Meisel, Joan, Daniel Chandler, and Beth Menees Rienzi. 2003. Domestic violence prevalence and effects on employment in two California TANF populations. *Violence Against Women* 9 (10): 1191-212.
- Menard, Anne. 2001. Domestic violence and housing: Key policy and program challenges. *Violence Against Women* 7 (6): 707-20.
- Merchant, Munira. 2000. A comparative study of agencies assisting domestic violence victims: Does the South Asian community have special needs? *Journal of Social Distress and the Homeless* 9 (3): 249-59.
- Midlarsky, Elizabeth, Anitha Venkataramani-Kothari, and Maura Plante. 2006. Domestic violence in the Chinese and South Asian immigrant communities. *Annals New York Academy of Sciences* 1087: 279-300.
- Moe, Angela M. 2007. Silenced voices and structured survival: Battered women's help seeking. *Violence Against Women* 13 (7): 676-99.
- Moe, Angela M., and Myrtle P. Bell. 2004. Abject economics: The effects of battering and violence on women's work and employability. *Violence Against Women* 10 (1): 29-55.
- Moracco, Kathryn E., Alison Hilton, Kathryn G. Hodges, and Pamela Y. Frasier. 2005. Knowledge and attitudes about intimate partner violence among immigrant Latinos in rural North Carolina. *Violence Against Women* 11 (3): 337-52.
- Murdaugh, Carolyn, Salena Hunt, Richard Sowell, and Irma Santana. 2004. Domestic violence in Hispanics in the Southeastern United States: A survey and needs analysis. *Journal of Family Violence* 19 (2): 107-15.

- Orbe, Mark, and Tina Harris. 2008. *Interracial communication: Theory into practice*. 2nd ed. Los Angeles: Sage Publications.
- Parker, Dawn, Steven Manson, Marco Janssen, Matthew Hoffmann, and Peter Deadman. 2003. Multi-agent systems for the simulation of land-use and land-cover change: A review. *Annals of the Association of American Geographers* 93 (2): 314-37.
- Pavao, Joanne, Jennifer Alvarez, Nikki Baumrind, Marta Induni, and Rachel Kimerling. 2007. Intimate partner violence and housing instability. *American Journal of Preventive Medicine* 32 (2): 143-6.
- Pollak, Robert. 2004. An intergenerational model of domestic violence. *Journal of Population Economics* 17: 311-29.
- Postmus, Judy L., Margaret Severson, Marianne Berry, and Jeong Ah Yoo. 2009. Women's experiences of violence and seeking help. *Violence Against Women* 15 (7): 852-68.
- Press, Julie, Janice Johnson-Dias, and Jay Fagan. 2005. Welfare status and child care as obstacles to full-time work for low-income mothers. *Journal of Women, Politics & Policy* 27 (3): 55-79.
- Raj, Anita, and Jay Silverman. 2002. Violence against immigrant women: The roles of culture, context, and legal immigrant status on intimate partner violence. *Violence Against Women* 8 (3): 367-98.
- Raj, Anita, and Jay G. Silverman. 2003. Immigrant South Asian women at greater risk for injury from intimate partner violence. *American Journal of Public Health* 93 (3): 435-7.
- Ranjan, Sheetal, and Chitra Raghavan. 2008. Spatial analysis of intimate partner violence: New York City. Abstract. *Paper presented at the annual meeting of the American Society of Criminology Annual meeting, St. Louis, Missouri*. Available from www.allacademic.com/meta/p269687_index.html.
- Rasche, Christine E. 1988. Minority women and domestic violence: The unique dilemmas of battered women of color. *Journal of Contemporary Criminal Justice* 4: 150-71.
- Renninson, Callie Marie. 2003. *Bureau of Justice Statistics crime data brief, intimate partner violence, 1993-2001*. Washington DC: U.S. Department of Justice, National Institute of Justice, NCJ 197838.
- Rhee, Siyon. 1997. Domestic violence in the Korean immigrant family. *Journal of Society and Social Welfare* 24 (1): 63-78.
- Riger, Stephanie, and Susan Staggs. 2004. *The impact of intimate partner violence on women's labor force participation*. Washington DC: U.S. Department of Justice, National Institute of Justice, NCJ 207143.

- Robinson, Amanda, and Meghan Chandek. 2000. Differential police response to Black battered women. *Women and Criminal Justice* 12 (2): 29-61.
- Romero, Diana, Wendy Chavkin, Paul Wise, and Lauren Smith. 2003. Low-income mothers' experience with poor health, hardship, work, and violence: Implications for policy. *Violence Against Women* 9 (10): 1231-44.
- Sabina, Chiara, and R. Scott Tindale. 2008. Abuse characteristics and coping resources as predictors of problem-focused coping strategies among battered women. *Violence Against Women* 14 (4): 437-56.
- Salari, Sonia Miner, and Bret M. Baldwin. 2002. Verbal, physical and injurious aggression among intimate couples over time. *Journal of Family Issues* 23 (4): 523-50.
- Sanders, Cynthia K., and Schnabel, Meg. 2006. Organizing for economic empowerment of battered women: Women's savings accounts. *Journal of Community Practice*, 14 (3): 47-68
- Schultz, Leroy G. 1960. The wife assaulter. *Journal of Social Therapy* 6 (2): 103-111.
- Senturia, Kirsten, Marianne Sullivan, Sandy Ciske, and Sharyne Shiu-Thornton. 2000. *Cultural issues affecting domestic violence service utilization in ethnic and hard to reach populations, final report*. Washington DC: U.S. Department of Justice, National Institute of Justice, NCJ 185357.
- Shirwadkar, Swati. 2004. Canadian domestic violence policy and Indian immigrant women. *Violence Against Women* 10 (8): 860-79.
- Snell, John E., Richard J. Rosenwald, and Ames Robey. 1964. The wifebeater's wife: A study of family interaction. *Archives of General Psychiatry* 11 (August): 107-113.
- Stephens, Joyce, and Peter Sinden. 2000. Victims' voices: Domestic assault victims' perceptions of police demeanor. *Journal of Interpersonal Violence* 15 (5): 534-47.
- Straus, Murray A. 2004. Women's violence toward men is a serious social problem. In *Current controversies on family violence*, eds. Richard Gelles, Donileen Loseke. 2nd ed., 55-77. Newbury Park: Sage Publications.
- Straus, Murray A. 1973. A general systems theory approach to a theory of violence between family members. *Social Science Information* 12 (3): 105-25.
- Straus, Murray A. 1974. Forward. In *The violent home: A study of physical aggression between husbands and wives*, ed. Richard J. Gelles, 13-17. Beverly Hills: Sage Publications.
- Straus, Murray A., Richard J. Gelles, and Suzanne K. Steinmetz. 1980. *Behind closed doors: Violence in the American Family*. Garden City, New York: Doubleday.

- Sugihara, Yoko, and Judith Ann Warner. 2002. Dominance and domestic abuse among Mexican Americans: Gender differences in the etiology of violence in intimate relationships. *Journal of Family Violence* 17 (4): 315-40.
- Sullivan, Cris M., Rebecca Campbell, Holly Angelique, Kimberly K. Eby, and William S. Davidson II. 1994. An advocacy intervention program for women with abusive partners: Six-month follow-up. *American Journal of Community Psychology* 22 (1): 101-22.
- Sullivan, Cris, Joanna Basta, Cheribeth Tan, and William S. Davidson II. 1992. After the crisis: A needs assessment of women leaving a domestic violence shelter. *Violence and Victims* 7 (3): 267-75.
- Sweet, Elizabeth, and Sara Ortiz Escalante. 2010. Planning responds to gender violence: Evidence from Spain, Mexico and the United States. *Urban Studies*: 1-19.
- Tjaden, Patricia, and Nancy Thoennes. 2000. *Full report of the prevalence, incidence, and consequences of intimate partner violence against women: Findings from the national violence against women survey*. Washington DC: U.S. Department of Justice, National Institute of Justice, NCJ 183781.
- Tolman, Richard M., and Daniel Rosen. 2001. Domestic violence in the lives of women receiving welfare: Mental health, substance dependence, and economic well-being. *Violence Against Women* 7 (2): 141-58.
- Tolman, Richard M., and Hui-Chen Wang. 2005. Domestic violence and women's employment: Fixed effects models of three waves of women's employment study data. *American Journal of Community Psychology* 36 (1/2): 147-58.
- Turner, Margery A., and Hayes, Christopher. Poor people and poor neighborhoods in the Washington metropolitan area. 1997. Available from <http://www.urban.org/publications/407425.html>.
- Ucko, Lenora Greenbaum. 1994. Culture and violence: The interaction of Africa and America. *Sex Roles* 31 (3/4): 185-204.
- Uekert, Brenda K., Tracy Peters, Wanda Romberger, Margaret Abraham, and Susan Keilitz. 2006. *Serving limited English proficient (LEP) battered women: A national survey of the courts' capacity to provide protection orders*. Washington DC: U.S. Department of Justice, National Institute of Justice, NCJ 216072.
- Valenzuela, Sylvia, Luis Flores, and Taryn Hanano. 2005. Legal aid and domestic violence in Orange and Los Angeles counties. Abstract. *Paper presented at the Annual meeting of the American Society of Criminology, Royal York, Toronto*. Available from www.allacademic.com/meta/p35095_index.html.

- Van Hightower, Nikki R., Joe Gorton, and Cassey Lee DeMoss. 2000. Predictive models of domestic violence and fear of intimate partners among migrant and seasonal farm worker women. *Journal of Family Violence* 15 (2): 137-54.
- Websdale, Neil, and Byron R. Johnson. 2005. Reducing woman battering: The role of structural approaches. In *Domestic violence at the margins : Readings on race, class, gender, and culture.*, eds. Natalie J. Sokoloff, Christina Pratt, 389-415. New Brunswick, N.J.: Rutgers University Press.
- West, Carolyn, Glenda Kaufman Kantor, and Jana Jasinski. 1998. Sociodemographic predictors and cultural barriers to help-seeking behavior by Latina and Anglo American battered women. *Violence and Victims* 13 (4): 361-75.
- Wilensky, U. 1999. *NetLogo*. Center for Connected Learning and Computer-Based Modeling, Evanston, IL: Northwestern University.
- Wilson, Steve, and Jana L. Jasinski. 2004. Public satisfaction with the police in domestic violence cases: The importance of arrest, expectations, and involuntary contact. *American Journal of Criminal Justice* 28 (2): 235-54.
- Wolf, Marsha E., Uyen Ly, Margaret A. Hobart, and Mary A. Kernic. 2003. Barriers to seeking police help for intimate partner violence. *Journal of Family Violence* 18 (2): 121-9.
- Worden, Alissa Politz, and Bonnie E. Carlson. 2005. Attitudes and beliefs about domestic violence: Results of a public opinion survey: II. beliefs about causes. *Journal of Interpersonal Violence* 20: 1219-43.
- Yick, Alice G. 2000. Predictors of physical spousal intimate violence in Chinese American families. *Journal of Family Violence* 15 (3): 249-67.
- Yick, Alice G., and Pauline Agbayani-Siewert. 1997. Perceptions of domestic violence in a Chinese American community. *Journal of Interpersonal Violence* 12 (6): 832-46.
- Yoshihama, Mieko. 2002. Battered women's coping strategies and psychological distress: Differences by immigration status. *American Journal of Community Psychology* 30 (3): 429-52.
- Yoshioka, Marianne R., Louisa Gilbert, Nabila El-Bassel, and Malahat Baig-Amin. 2003. Social support and disclosure of abuser: Comparing South Asian, African American, and Hispanic battered

APPENDIX A: LIST OF HOUSING⁷

Name	Address	Zipcode	Type of housing	Beds	Max time A (days) ⁸	Max time B (days) ⁹
Deborah's Place Rebecca Johnson Apartments	2822 W. Jackson Blvd	60612	apartment	90	9999999	1095
Deborah's Place Patty Crowley Apartments	1530 N. Sedgwick Ave	60610	apartment	39	9999999	1095
Franciscan Outreach Association, House of Mary & Joseph	2715 W. Harrison Street	60612	emergency	37	0	120
Great Hope Family Center (La Cruzada)	2622 W Cermak Rd	60608	emergency/interim	80	120	120
Port Ministries/Theresa House	5017 S. Hermitage Ave	60609	full family shelter	65	120	120
REST	1011 W. Wilson Ave	60640	homeless shelter	40	120	120
Southwest Women Working Together Amani House	11740 S. Lowe	60628	homeless	8	0	120
Southwest Women Working Together Amani House	11740 S. Lowe	60628	IDV shleter	24	0	120
Apna Ghar	4753 N Broadway	60640	IDV shelter	60	90	90
Apna Ghar	4753 N Broadway	60640	interim	7	540	540
Greenhouse Shelter	2339 N. California Ave	60647	IDV shelter	42	120	120
House Of The Good Shepherd	1343 W Irving Park Rd	60613	IDV shelter	80	105	105
Rainbow House	20 East Jackson Blvd	60604	IDV shelter	42	0	120
Neopolitan Lighthouse	1859 S. Ashland Ave	60608	IDV shelter	25	90	90
Sylvia Center	4615 N. Clifton Ave	60640	interim	90	0	120
Deborah's Place/Theresa's Place	1532 N. Sedgwick Ave	60610	interim	10	120	120
Naomi Housing	4615 North Clifton Ave	60640	emergency	165	120	120
TAB South I Interim	8714 S Paulina St	60620	interim	90	0	120
TAB South II Interim	313 E. 137th St	60827	interim	125	0	120
Family Restoration House/Inner voice	9519 S. Commerical Ave.	60617	interim	50	0	120
It Takes A Village/Inner Voice	544 W. 123rd St	60628	interim	60	0	120
Interfaith House Transitional Living	3465 W. Franklin Blvd	60624	interim	64	0	120
Thelma's Place Interim	8040 S. Western Ave	60652	interim	50	0	120
Ubuntu Community Center	2905 W. 43rd St	60632	interim	75	0	120
New Life Shelter/Good News Partners	7632 N.Paulina	60626	interim	32	0	120

⁷ Identical names indicate multiple locations for the same agency.

⁸ Max time A is a maximum time of stay according to the websites of corresponding agencies. "0" indicates no data. "9999999" indicates unlimited stay.

⁹ Max time B is a maximum time of stay that was extrapolated for the unknown values. Thus, "9999999" values were converted into "1095" and "0" values were converted into "120". The reason for extrapolation of values was the overall lack of data. 120 days of stay appear to be common in many shelters and short-term housing and hence the value was used. The option of unlimited stay was not appropriate for the purpose of the model and hence it was replaced with 1095 days of stay (a maximum value in the original sample).

APPENDIX A (cont.)

Name	Address	Zipcode	Type of housing	Beds	Max time A (days)	Max time B (days)
Lincoln Park Community Shelter	642 West Deming Place	60614	interim	35	0	120
Cry for Hope/Great Hope Family Center	2620-22 W. Cermak	60616	emergency/interim	80	120	120
St. Elizabeth Catholic Worker	8025 S. Honore	60620	homeless shelter	7	0	120
Breakthrough Urban Ministries - Women's Services	3330 W. Carroll Ave	60624	emergency	30	0	120
Deborah's Place/Marah's Place	1456 W. Oakdale Ave.	60657	permanent	30	9999999	1095
Cornerstone Community Outreach/Hannah House	4628 North Clifton Ave	60640	interim/family	22	0	120
Bickerdike Redevelopment Corporation	2550 W. North Ave	60647	rentals and coops	918	9999999	1095
REST/Epworth	5253 N. Kenmore St	60640	seasonal shelter	65	0	120
Lincoln Park Community Shelter	600 W Fullerton Pkwy	60614	unknown shelter	11	0	120
Chicago Christian Industrial League	618 S. Wabash Ave	60605	single room occupancy	169	9999999	1095
Chicago Christian Industrial League	1801 S.. Wabash Ave	60605	single room occupancy	170	9999999	1095
New Moms	2845 W Mclean Ave # 2	60647	transitional	20	720	720
Casa Esperanza	8801 S. Saginaw	60617	transitional	20	365	365
Featherfist/Hope Village	2255 East 75th St	60649	transitional	20	0	120
Featherfist Apts	2257 East 75th St	60649	permanent	52	9999999	1095
Featherfist/Supportive Housing Program	2259 East 75th St	60649	permanent	28	9999999	1095
Featherfist/East Park	2261 East 75th St	60649	permanent	152	9999999	1095
Leland House	4656 N Malden St 1	60640	transitional	18	720	720
St. Martin de Porres House of Hope Inc.	6423 South Woodlawn Ave	60644	women's shelter	40	0	120

APPENDIX B: LIST OF COMMUNITY SERVICE CENTERS

Name	Address	Zipcode	ESL ¹⁰	GED ¹¹	Emergency service	Children's service	Housing Aid
Albany Park Community Center	3403 West Lawrence Ave	60625	0	1	0	1	1
Albany Park Community Center	3401 West Ainslie Ave	60625	0	0	0	1	0
Albany Park Community Center	5101 North Kimball Ave	60625	1	1	0	0	0
Aquinas Literacy Center	3525 S. Hermitage	60609	1	0	0	0	0
Asian Human Services	6015 N Francisco Ave	60659	1	1	0	0	0
Asian Human Services	4753 N Broadway	60640	1	1	0	0	0
Association House/The Learning Place	1116 N Kedzie Ave	60651	1	1	1	0	0
Brainerd Community Development Corporation	1234 W. 95 St	60643	0	1	0	0	0
Brainerd Community Development Corporation	1234 W. 95th St	60643	0	1	0	0	0
Cambodian Association of Illinois	2831 W. Lawrence Ave	60625	1	1	0	0	0
Casa Aztlan	1831 S. Racine Ave	60608	1	1	1	0	0
Centro Romero IDV serv	6216 N. Clark St	60660	1	1	0	0	0
Chicago Commons ETC	700 N Sacramento Blvd	60612	1	1	0	0	0
Children's Home Aid Mitzi Freidheim	1701 West 63rd St	60636	0	1	0	0	0
Chinese American League	2141 South Tan Court	60616	1	0	0	1	1
Chinese Mutual Aid Society	1016 W. Argyle	60640	1	0	0	0	1
Christopher House	2507 N. Greenvew Ave	60614	1	1	1	0	0
Concordia Avondale Campus	3300 N Whipple St	60618	1	1	0	0	0
Corazon A Corazon	8235 South Shore Drive	60617	1	1	0	0	0
Erie Neighborhood House	4225 W. 25th St	60623	1	1	0	0	0
Erie Neighborhood House	2510 W. Cortez St	60622	0	1	0	0	0
Erie Neighborhood House	1701 W. Superior St	60622	0	1	1	1	0
Erie Neighborhood House	1347 W. Erie St	60622	1	1	0	0	0
Gads Hill Center	1919 W. Cullerton St	60608	1	0	0	0	0
Greater West Town	790 N. Milwaukee Ave	60642	0	1	0	0	0
Heartland Human Care Services	208 S. LaSalle St	60604	0	1	1	0	1
Hispanic Housing Development Corporation	2610 W. North Ave	60647	1	1	0	0	0
Hispanic Housing Development Corporation	325 North Wells St	60654	1	1	0	0	0
Howard Area Community Center	7648 N.Paulina St.	60626	1	1	1	0	0

¹⁰ 0 indicates absence of the service; 1 indicates presence of the service

¹¹ GED includes different categories of education: GED, ABE, Literacy, IT or other specialized classes.

APPENDIX B (cont.)

Name	Address	Zipcode	ESL	GED	Emergency service	Children's service	Housing Aid
Iglesia de la Santa Cruz	6524 South Springfield	60629	1	0	0	0	0
Infant Welfare Society	3600 West Fullerton	60647	1	0	0	0	0
Instituto del Progreso Latino	2570 S Blue Island Ave	60608	0	1	0	0	0
Jewish Vocational Service	6526 North California Ave	60645	1	0	0	0	0
Jobs For Youth Chicago, Inc.	17 N. State St.	60602	1	0	0	0	0
Kennedy-King College, Adult Learning Skills	747 W. 63rd St	60621	1	1	0	0	0
Korean American Community Services	4300 North California Ave	60618	1	0	0	0	0
Lakeview Learning Center	3310 N. Clark St	60657	1	1	0	0	0
Lao American Community Services	4750 N. Sheridan Rd	60640	1	1	0	0	0
Literacy Chicago	17 N State	60602	0	1	1	1	1
Malcom X Community College	4624 W Madison St	60644	1	1	0	0	0
Malcom X Community College	1900 W. Van Buren	60612	1	1	0	0	0
National Latino Education Institute	2011 W. Pershing Rd	60609	1	1	0	0	0
NEIU's El Centro	3119 N Pulaski Rd	60641	1	0	0	0	0
Olive-Harvey College	10001 S Woodlawn Ave	60628	1	1	0	0	0
Poder Learning Center	1637 S Allport	60608	1	1	0	0	0
Polish-American Association	6276 S Archer Ave	60638	1	1	0	0	0
Pui Tak Center	2216 S. Wentworth	60616	1	1	0	0	0
Richard J. Daler College	7500 S. Pulaski Rd	60652	1	1	0	0	0
South East Asia Center	5120 N. Broadway St	60640	1	0	0	0	0
South East Asia Center	1124-1134 W. Ainslie St	60640	1	0	0	0	0
South East Asia Center	1112-1118 W. Foster Ave	60640	1	1	0	0	0
Spanish Coalition for Jobs, Inc.	2011 W Pershing Rd	60609	1	1	0	0	0
The Allison United Foundation for Better Living	4540 W. Washington Ave	60624	0	1	1	0	0
Tolton Center	3647 South State St	60609	1	1	0	0	0
Truman community College	1145 W. Wilson Ave	60640	1	1	0	0	0
United Neighborhood Organization	954 West Washington Blvd	60607	1	0	0	0	0
Universidad Popular	2801 S Hamlin Ave	60623	1	1	0	0	0
Vietnamese Association of Illinois	5110 N. Broadway	60640	1	1	0	0	0
Wilbur Wright College	4300 N. Narragansett	60634	1	1	0	0	0
World Relief Chicago	3507 W. Lawrence Ave	60625	1	1	0	0	0

APPENDIX C: REGRESSIONS

Table 6. Regression Coefficients and (Adjusted Odds Ratios). Aggression Level in Dyads (after Salari and Baldwin 2002).

Variable	Verbal Aggression	Physical Aggression	Injurious Aggression
Black (versus White)	0.073 (1.07)	0.662*** (1.94)	0.166 (1.18)
Hispanic (versus White)	-0.360* (0.70)	0.035 (1.03)	-0.079 (0.92)
Household income	-0.008 (0.99)	-0.037 (0.96)	-0.165* (0.85)
Female percent income	-0.001 (0.99)	-0.001 (0.99)	0.009** (1.01)
Male traditional gender roles	0.100 (1.10)	-0.007 (0.99)	0.473* (1.60)
Female traditional gender roles	-0.090 (0.91)	-0.012 (0.98)	-0.047 (0.95)
Dependent child	0.286** (1.33)	0.430** (1.54)	0.422* (1.52)
Cohabiting (versus married)	-0.539*** (0.58)	0.403* (1.49)	0.491 (1.63)
Relationship duration	-0.010*** (0.99)	-0.067*** (0.93)	-0.051*** (0.95)
Male family contact	0.012 (1.01)	-0.009 (0.99)	0.039 (1.04)
Female family contact	-0.012 (0.99)	-0.001 (0.99)	-0.108* (0.89)
Social outings	0.035** (1.04)	0.033 (1.03)	0.004 (1.00)
Crisis support	-0.254** (0.77)	0.063 (1.06)	-0.339 (0.71)
Male drug problem	0.689*** (2.00)	1.147*** (3.15)	1.910*** (6.80)
Female drug problem	0.221 (1.24)	0.931* (2.53)	1.47** (4.37)
Male esteem	-0.130** (0.88)	-0.145 (0.86)	-0.296** (0.74)
Female esteem	-0.182*** (0.83)	-0.306*** (0.73)	-0.403*** (0.67)
Intercept	0.6	-0.42	0.70
-2 Log L $\chi^2(18)$	124.19***	229.44***	183.34***
Number of couples	1,497	279	136

Note: No aggression in the reference category (n = 2,196); * p < 0.05. ** p < 0.01. *** p < 0.001.

APPENDIX C (cont.)

Table 7. Logistic Regression Examining Correlates of Help-Giving Among Acquaintances of Survivors of Intimate Partner Violence (after Beeble et al. 2008).

Variable	Coefficient (odds ratios)
Sex	0.17* (1.18)
Age	-0.01** (0.99)
Attitudes and beliefs about helping victims of IPV	0.12* (1.13)
Childhood exposure to IPV	0.30** (1.35)
Personal exposure to IPV	0.35** (1.42)
Perceived prevalence rates of IPV	0.12** (1.13)
Constant	-0.41**

Note: Likelihood ratio $\chi^2 = 656.42$ ($df = 6$), $p < 0.001$; * $p < 0.01$. ** $p < 0.001$.

Table 8. Logistic Regression Analysis Predicting Leaving Abuser (after Sabina and Tindale 2008).

Variable	Coefficient	Standard Error	Wald χ^2	Odds Ratio
Log incidents in year	-0.31	0.22	1.99	0.73
Most severe incident	0.03	0.13	0.05	1.03
Harassment	0.14***	0.04	13.01	1.15
Power and control	0.23*	0.09	6.26	1.26
General health	0.20*	0.10	3.85	1.22
Lack of depression	-0.01	0.08	0.01	0.99
Education level	0.10	0.09	1.26	1.11
Personal income	-0.02	0.09	0.07	0.98
Employment: PT/FT	-0.19	0.25	0.58	0.83
Employment: Homemaker	-1.75***	0.50	12.40	0.17
Employment: Student	-0.25	0.34	0.55	0.78
Support network	0.02	0.04	0.13	1.02

Note: Nagelkerke $R^2 = 0.22$; * $p < 0.05$. *** $p < 0.001$.

APPENDIX C (cont.)

Table 9. Multinomial Logistic Regression of Victim and Third Party Reporting vs. Not Reporting (after Felson et al. 2005).

	Victim Reporting			Third Party Reporting		
	Coefficient	SE	Odds ratio	Coefficient	SE	Odds ratio
Sexual offence	-0.329*	0.126	0.720	0.040	0.146	1.041
Partner	-0.964*	0.155	0.381	-1.481*	0.198	0.227
Other family	-1.595*	0.212	0.203	-1.202*	0.212	0.301
Other known	-1.079*	0.112	0.340	-0.955*	0.138	0.385
Male offender	0.361	0.230	1.435	-0.050	0.248	0.951
Gun	1.196*	0.115	3.307	1.313*	0.135	3.717
Other weapon	0.629*	0.097	1.876	0.855*	0.111	2.351
Unknown weapon	0.225	0.419	1.252	-0.180	0.624	0.835
Physical injury	0.999*	0.078	2.176	1.020*	0.092	2.773
Unknown injury	-0.289	0.502	0.749	0.373	0.611	1.452
Offender used alcohol	0.456*	0.101	1.578	0.669*	0.136	1.952
Offender used drugs	0.918*	0.121	2.504	0.908*	0.161	2.479
Unknown alcohol/drug use by offender	0.819*	0.109	2.268	0.822*	0.141	2.275
Victim used alcohol	-1.146*	0.125	0.318	-0.387*	0.128	0.679
Victim used drugs	-0.994*	0.249	0.370	-0.838*	0.309	0.432
Unknown alcohol/drug use by victim	-0.192	0.276	0.825	-0.168	0.344	0.845
Victim precipitation	-0.495*	0.171	0.610	0.203	0.200	0.816
Unknown victim precipitation	-0.692*	0.227	0.501	-0.717*	0.295	0.488
Home	0.293*	0.105	1.340	0.189	0.134	1.208
Unknown location	-0.040	0.256	0.961	-0.890	0.480	0.411
1-4 prior victimizations	-0.065	0.091	0.937	-0.215	0.122	0.807
5 and more prior victimization	0.222	0.118	1.249	0.221	0.149	1.247

APPENDIX C (cont.)

Table 9 (cont.)

	Victim Reporting			Third Party Reporting		
	Coefficient	SE	Odds ratio	Coefficient	SE	Odds ratio
1970s	-0.105	0.175	0.900	-0.257	0.194	0.773
1980s	0.231	0.164	1.260	0.115	0.185	1.122
1990s	0.629*	0.163	1.876	0.285	0.287	1.330
Unknown decade	1.153*	0.311	3.168	-0.891*	0.377	0.410
Victim 30 and older	0.356*	0.080	1.428	0.144	0.109	1.155
Victim less than 18 years old	-0.640*	0.164	0.527	0.311*	0.136	1.365
Victim age unknown	-0.941*	0.292	0.390	0.173	0.256	1.189
Victim man	0.248	0.250	1.281	-0.806*	0.331	0.447
Victim education	0.013	0.035	1.013	-0.117*	0.043	0.890
Victim Black	0.273*	0.116	1.314	0.070	0.155	1.073
Victim Hispanic	-0.084	0.174	0.919	0.032	0.178	1.033
Victim Other/Unknown race	0.154	0.133	1.166	0.151	0.164	1.163
Victim high income	-0.038	0.123	0.963	-0.137	0.156	0.872
Victim low income	-0.165	0.090	0.848	-0.135	0.108	0.874
Victim unknown income	0.213	0.118	1.237	-0.012	0.151	0.988
Constant	-2.245*	0.337		-1.810*	0.384	

Note: *p < 0.05.

APPENDIX C (cont.)

Table 10. Logistic Regression Predicting Employment by Employment Barriers for Women (after Blumenberg 2002)

Parameter	Estimate	Std. Error
Intercept	-0.372***	0.009
Education	-0.718***	0.011
Language	-0.386***	0.013
Travel by transit	-0.810***	0.012
Children	-0.266***	0.010
Health	-0.806***	0.016

Note: -2 log likelihood = 269,781; *** p < 0.01.

APPENDIX D: SOURCE CODE

Global variables:

```
globals [  
  
    resultOfCalculation          ;; a global variable used to calculate the regression  
    services-variable-array      ;; an array containing names of the community center services  
    services-weight-array       ;; an array containing values that determine weight of center services  
    numberOfServices            ;; a values that determines a total number of all community center services  
    time-step                   ;; time step for the model  
    timeCount                   ;; time counter increment  
    factor                      ;; converts NetLogo distances into geographic distances  
    eastingOrigin               ;; is used to calculate easting and northing  
    northingOrigin  
    a                           ;; a value that is set to 1 for a distance decay function  
    chicago-dataset             ;; a shapefile with Chicago boundary  
    cultural-centers-dataset     ;; a shapefile with info on educational and community/cultural centers  
    police-areas-dataset        ;; a shapefile with boundaries of police areas  
    community-areas-dataset     ;; a shapefile with boundaries of community areas  
    city-boundary-dataset       ;; a raster file with Chicago boundaries  
    chicago-tracts-dataset      ;; a shapefile with boundaries of tract areas  
  
    ;; intercepts or constants for the regressions  
    constantPhysicalViolence  
    constantVerbalViolence  
    constantInjuryViolence  
    constantSeekingHelp  
    constantHelpVictims  
    constantVictimCallingPolice  
    constantThirdPartyCallingPolice  
    constantLowIncomeEmplt  
  
    ;; arrays containing coefficients for the regressions  
    violence-variable-array  
    leaving-abuser-variable-array  
    helping-victims-variable-array  
    calling-police-variable-array  
    variable-array-low-income-mother-emplt  
    coefficient-verbal-violence-array  
    coefficient-physical-violence-array  
    coefficient-injury-violence-array  
    coefficient-getting-amount-help-array  
    coefficient-leaving-abuser-array  
    coefficient-helping-victims-array  
    coefficient-victim-calling-police-array  
    coefficient-third-party-calling-police-array  
    coefficient-array-low-income-mother-emplt  
  
    ;; yearly, monthly and weekly counter increments  
    month-count  
    year-count  
    week-count  
]
```

Household variables:
(only used during the setup procedure to attach these data to a human agent)

households-own [

;; ACS variables

FS	;; whether a family receives food stamps
VEH	;; presence of a vehicle
HHT	;; household type (family, married, single etc)
HINCP	;; household income
HUPAC	;; children in a household
MV	;; years when moved to the house
PARTNER	;; whether an unmarried partner
householdIDHH	; household's unique number

]

Human agent variables:
(some are used only during the setup procedure temporarily)

persons-own [

householdIDP	; person's unique number
commIDP	; determines to what police district the person belongs to
sampledMarriedWoman	; temp
sampledMarriedMan	; temp
sampledUnmarriedMan	; temp
sampledUnmarriedWoman	; temp
whiteNonHisp	; White non-Hispanic
myTractID	; tract number in which a person lives
booleanChild	; whether a woman has a child under age 5
monthlyPhysicalInjuries	; counter of physical violent acts
monthlyInjuriousInjuries	; counter of injurious violent acts
totalVictims	; counter of how many persons experienced violence
randHomelessTime	; determines how long a person is willing to be homeless
lifeTimeExposure	; whether a person experienced violence at least once
shelterList	; an array of shelters for a given person
welfare-place-list-regular	; an array of community services centers
welfare-place-selected	; a community service center that a person selects
sampledFemaleHead	; married or cohabiting woman of White, Black or Hispanic race
sampledMaleHead	; a temp
your-home	; patch location of the household
isHurtPhysically?	; boolean if physical violence happened
isHurtInjuriously?	; boolean if injurious violence happened
monthlyCountActsPerPerson	; counter incidents per person
#PoliceDistrict	; what police district the person associates with
totalViolenceActs	; counter for total violent acts per lifetime
receivedInformalSupport?	; Boolean whether received help from friends
childCareClock	; counter that determines how long a child can be in a care program
foundChildCare?	; Boolean whether a person found childcare
foundFinAid?	; Boolean whether a person found financial aid
foundHouseAid?	; Boolean whether a person found housing aid
in-need-for-money	; Boolean whether a person needs money
in-need-for-home	; Boolean whether a person needs housing assistance
in-need-for-education	; Boolean whether a person needs education (ESL or GED classes)
in-need-for-childcare	; Boolean whether a person needs childcare
probHuff	; Huff probability for selecting a community center to visit

welfare-place-list	<i>; an array of community services centers</i>
welfare-place-list1	<i>; an array of community services centers</i>
own-welfare-place-list	<i>; an array of community services centers</i>
own-welfare-place-list1	<i>; an array of community services centers</i>
welfare-place-list1a	<i>; an array of community services centers</i>
householdIncome	<i>; housing income</i>
HHstatus	<i>; household status (whether married etc)</i>
PartnerStatus	<i>; whether cohabiting or not</i>
malePartner	<i>; whether a male partner is in the household</i>
malePartnerAge	<i>; male age</i>
malePartnerRace	<i>; male race</i>
malePartnerHISP	<i>; male Hispanic or not</i>
MVpersons	<i>; when moved to the household</i>
my-friends	<i>; array of friends</i>
friend-id	<i>; temp</i>
memory-of-friend-help	<i>; memory array holding how much friends helped</i>
memory-police-help	<i>; memory array holding how much police helped</i>
memory-welfare-help	<i>; memory array holding how much community centers and shelters helped</i>
myShelter	<i>; a selected shelter (i.e., shelter where the person is staying at)</i>
Range	<i>; income range</i>
talkedToFriend?	<i>; Boolean whether a person talked to a friend</i>
levelOfSupport	<i>; level of support from friends</i>
shelterClock	<i>; counter how long a person is in a shelter</i>
homelessClock	<i>; counter for homelessness</i>
currentlyInShelter?	<i>; Boolean whether in shelter</i>
gotService?	<i>; Boolean whether got service</i>
monthlyPoliceCalls	<i>; counter of police calls per person</i>
leftAbuser?	<i>; Boolean whether left abuser</i>
probabilityPersonBecameHomeless	<i>; prob whether a person became homeless</i>
isHomeless?	<i>; Boolean whether homeless</i>
foundService?	<i>; Boolean whether found service</i>
visitedShelter?	<i>; Boolean whether visited shelter</i>
probVisitShelter	<i>; prob of visiting a shelter</i>
visitedServiceLocation?	<i>; Boolean whether visited community center</i>
foundEducService?	<i>; Boolean whether found educational services</i>
educationClock	<i>; counter for being in class</i>
availableForJobSearch	<i>; Boolean whether person can look for a job</i>
isCurrentlySafe?	<i>; Boolean whether out of the relationship</i>
booleanBlack	<i>; Boolean whether race is Black</i>
HHincomeTenths	<i>; household income divided by 1000</i>
F%income	<i>; woman's income share</i>
booleanMrole	<i>; male traditional family role</i>
booleanFrole	<i>; female traditional family role</i>
booleanChildUnder5	<i>; presence of a child</i>
booleanCohabiting	<i>; whether married or cohabiting</i>
relationshipDuration	<i>; how long together</i>
MFamilyContact	<i>; number of male's friends</i>
FFamilyContact	<i>; number of female's friends</i>
numberSocialOutings	<i>; couple's friends</i>
booleanCrisisSupport	<i>; whether at least one contact present</i>
booleanFDrugProblem	<i>; female's alcohol problem</i>
booleanMDrugProblem	<i>; male's alcohol problem</i>
Mesteem	<i>; male's esteem</i>
Festeem	<i>; female's esteem</i>
numberFriends	<i>; person's friends</i>
coupleFriends	<i>; couple's friends</i>

probabilityOfVerbalViolence	<i>; prob of verbal violence</i>
probabilityOfPhysicalViolence	<i>; prob of physical violence</i>
probabilityOfInjuryViolence	<i>; prob of injuriousviolence</i>
partnersDrugProblem	<i>; presence of alcohol problem</i>

;variables for calculating probability of helping victims of IPV

booleanFemale
 helperAgeFemale
 helperAgeMale
 beliefHelpingVictimsIPV
 childhoodExposureIPV
 personalExposureIPV
 perceivedPrevalenceRatesIPV
 probabilityPersonHelped
 helpedVictim?

;variables for calculating probability a victim called police

booleanSexOffense
 booleanPartner
 booleanOtherFamily
 booleanOtherKnown
 booleanMaleOffender
 booleanGun
 booleanOtherWeapon
 booleanUnknownWeapon
 booleanPhysicalInjury
 booleanUnknownInjury
 booleanOffenderUsedAlcohol
 booleanOffenderUsedDrugs
 booleanUnknownAlcoholDrugUseOffender
 booleanVictimUsedAlcohol
 booleanVictimUsedDrugs
 booleanUnknownAlcoholDrugUseVictim
 booleanVictimPrecipitation
 booleanUnknownVictimPrecipitation
 booleanHome
 booleanUnknownLocation
 booleanOnetoFourPriorVictimization
 booleanFivePlusPriorVictimization
 booleanUnknownNumberPriorVictimization
 boolean1970s
 boolean1980s
 boolean1990s
 booleanUnknownDecade
 booleanVictim30Plus
 booleanVictim18Minus
 booleanVictimAgeUnknown
 booleanMen
 booleanEducation
 booleanAfrAmerican
 booleanHispanic
 booleanOtherUnknownRace
 booleanHighIncome
 booleanLowIncome
 booleanUnknownIncome

```

booleanMaleVictimXPartner
booleanMaleVictimXMaleOffender
booleanSexualAssaultXOtherKnown
probabilityVictimCalledPolice
probabilityThirdPartyCalledPolice
victimCalledPolice?

```

;;variables for calculating help seeking strategies (aka leaving abuser)

```

logIncidentsYear
mostSevereIncident
harassmentLevel
powerControlLevel
healthLevel
lackOfdepression
educationLevel
personalIncome2
booleanEmployedPTorFT
booleanStudent
booleanHomemaker
supportNetwork
severityBysupport
probabilityPersonLeftAbuser
rangeSeveretyIncident
educationRange

```

;;variables predicting low-income mothers finding FT employment

```

booleanWelfareRecipient
booleanHealthProblem
booleanLowEducation
booleanEnglishDif
booleanNoCar
personAge
probabilityLowIncomeMomFoundJob
lowIncomeMomFoundJob?

```

; ACS variables

AGEP	<i>; age</i>
CIT	<i>; citizenship status</i>
COW	<i>; worker status</i>
ENG	<i>; English ability</i>
SCHG	<i>; School attainment</i>
SCHL	<i>; School enrollment</i>
SEX	<i>; male or female</i>
HISP	<i>; Hispanic or not</i>
NATIVITY	<i>; foreiegn-born or not</i>
PINCP	<i>; person's income</i>
POVPIP	<i>; poverty status</i>
RAC1P	<i>; race</i>
REL	<i>; relationship to the head of the household</i>

]

Community service center variables

```
welfare-places-own [  
  ESL ; ESL classes  
  GED ; GED classes  
  emergency_service ; availability of financial emergency assistance  
  children_service ; availability of child care  
  housing_assist ; availability of housing assistance  
  housing ; availability of housing assistance  
  maxEducationTime ; how long a person can take classes (arbitrary variable)  
  education ; presence of GED classes  
  childcare ; availability of child care  
  fin_needs ; availability of financial emergency assistance  
  attractiveness-calculation ; used to calculate attractiveness index  
  commIDWP ; used to determine in which community area the center is located  
]
```

Shelter variables

```
shelters-own [  
  beds ; # of shelter beds  
  #requests ; how many people wanted to get a shelter bed  
  #grantedservice ; how many people received shelter beds  
  #returnedbeds ; how many people left shelters  
  totalBeds ; # of beds across all shelters  
  allBeds ; # of beds in a given shelter  
  availableBeds ; currently available beds in a given shelter  
  numberOfVisitsShelter ; how many people visited a given shelter  
  grantedService? ; whether a shelter provided a bed  
  maxShelterTime ; maximum number of time-steps a person can stay at a shelter  
  max_time ; max number of days a person can stay (original value)  
  _ID ; shelter ID  
  value2 ; one of temp variables  
  type_code ; determines shelter type (homeless, domestic etc)  
  any_serv ; one of temp variables  
  _temp ; one of temp variables  
]
```

Setup procedures:

to setup

;;; setup GIS data

```
ca  
set chicago-dataset gis:load-dataset "gis-data/chicago_boundary.shp"  
set city-boundary-dataset gis:load-dataset "gis-data/chicago_boundary90.asc"  
set police-areas-dataset gis:load-dataset "gis-data/police_areas90.asc"  
set community-areas-dataset gis:load-dataset "gis-data/community_areas90.asc"  
set chicago-tracts-dataset gis:load-dataset "gis-data/chicago_tracts90.asc"  
  
gis:set-world-envelope (gis:envelope-union-of -dataset 0 0)  
  (gis:raster-world-envelope police-areas-dataset 0 0)  
  (gis:raster-world-envelope community-areas-dataset 0 0)  
  (gis:raster-world-envelope chicago-tracts-dataset 0 0))
```

```

gis:apply-raster police-areas-dataset police-areas
gis:apply-raster city-boundary-dataset city-boundary
gis:apply-raster community-areas-dataset community-areas
gis:apply-raster chicago-tracts-dataset chicago-tracts
ask patches [ set pcolor white ]
gis:set-drawing-color black
gis:draw chicago-dataset 1

let world-envelope (gis:envelope-union-of
  (gis:raster-world-envelope city-boundary-dataset 0 0)
  (gis:raster-world-envelope police-areas-dataset 0 0)
  (gis:raster-world-envelope community-areas-dataset 0 0)
  (gis:raster-world-envelope chicago-tracts-dataset 0 0))

let gis-width (item 1 world-envelope - item 0 world-envelope)
let gis-height (item 3 world-envelope - item 2 world-envelope)

set eastingOrigin (item 1 world-envelope + item 0 world-envelope) / 2.0
set northingOrigin (item 3 world-envelope + item 2 world-envelope) / 2.0

set factor max list (gis-width / world-width)
  (gis-height / world-height)

;; load household and other data

read-households-file
read-persons-file
read-shelters-file
read-services-file
read-police-stations-file

;; setup parameters for all agents

ifelse Center-status = "original capacity"
[ ; do nothing ]
[ ask welfare-places [
  set housing_assist 0
  set legal_service 0
  set emergency_service 0
  set ESL 0
  set GED 0
  set children_service 0
  set _temp 0 ]

ask n-of center-capacity welfare-places
[
  set housing_assist 1
  set legal_service 1
  set emergency_service 1
  set ESL 1
  set GED 1
  set children_service 1
  set _temp 1 ]]

ask welfare-places [if _temp = 0 [ die] ]

```

```

ask persons-on patches
[ set #PoliceDistrict police-areas
  set commIDP community-areas]

ask welfare-places-on patches [set commIDWP community-areas]
let sorted-households sort-by [ [householdIDHH] of ?1 < [householdIDHH] of ?2 ] households

ask persons
[
  set memory-of-friend-help []
  set memory-police-help []
  set memory-welfare-help []

  let match match-id sorted-households householdIDP

  set householdIncome [HINCP] of match
  set HHStatus [HHT] of match
  set partnerStatus [PARTNER] of match
  set MVpersons [MV] of match
  if [VEH] of match = 0 [set booleanNoCar 1]
  if [FS] of match = 1 [set booleanWelfareRecipient 1]

  let _booleanChildUnder5 [HUPAC] of match
  if _booleanChildUnder5 = 1
  [
    set booleanChildUnder5 _booleanChildUnder5
    set booleanChild _booleanChildUnder5 ]

  if (RAC1P = 1 and HISP = 1) [set booleanHispanic 0]
  if (RAC1P = 1 and HISP >= 2) [set booleanHispanic 1]
  if (RAC1P = 2 and HISP = 1) [set booleanBlack 1]
  if (RAC1P = 2 and HISP >= 2) [set booleanHispanic 1]
  if (RAC1P = 1 and HISP = 1) [set booleanBlack 0]
  if (RAC1P >= 3 and HISP >= 2) [ set booleanHispanic 1 ]
  if (RAC1P = 1 and HISP = 1) [ set whiteNonHispanic 1 ] ]

ask persons
[
  if ((SEX = 1) and (HHStatus = 1) and (REL = 0 or REL = 1))
  [ set sampledMarriedMan 1 ]

  if ((SEX = 1) and (partnerStatus = 2 or partnerStatus = 4) and (REL = 0 or REL = 13))
  [ set sampledUnmarriedMan 1 ]

  if ((SEX = 2) and (HHStatus = 1) and (REL = 0 or REL = 1))
  [ set sampledMarriedWoman 1 ]
  if ((SEX = 2) and (partnerStatus = 2 or partnerStatus = 4) and (REL = 0 or REL = 13))
  [ set sampledUnmarriedWoman 1 ] ]

ask persons
[ setup-data-on-substance-abuse-problems ]

ask persons with [ AGE >= 15 ]
[
  let randValue random-float 1
  ifelse randValue < 0.27

```

```

[ set numberFriends vary 10 12]
[ ifelse randValue >= 0.27 and randValue < 0.45
[set numberFriends vary 6 9]
[ ifelse randValue >= 0.45 and randValue < 0.62
[set numberFriends 5]
[ ifelse randValue >= 0.62 and randValue < 0.74
[ set numberFriends 4]
[ ifelse randValue >= 0.74 and randValue < 0.85
[ set numberFriends 3]
[ ifelse randValue >= 0.85 and randValue < 0.93
[ set numberFriends 2]
[ ifelse randValue >= 0.93 and randValue < 0.99
[ set numberFriends 1]
[ set numberFriends 0]
]
]
]
]
]
]
]
]

if randValue < 0.37 [set childhoodExposureIPV 1]

if (SEX = 2)
[ifelse randValue < 0.671
[ set Festeem 3]
[ifelse randValue >= 0.671 and randValue < 0.884
[set Festeem 2]
[ifelse randValue >= 0.884 and randValue < 0.96
[ set Festeem 1 ]
[ set Festeem 0 ]
]
]
]

if (SEX = 1)
[ifelse randValue < 0.663
[set Mesteem 3]
[ifelse randValue >= 0.663 and randValue < 0.872
[set Mesteem 2]
[ifelse randValue >= 0.872 and randValue < 0.95
[ set Mesteem 1]
[set Mesteem 0 ]
]
]
]

if SEX = 1 and randValue < 0.5 [set booleanMrole 1]
if SEX = 2 and randValue < 0.425 [set booleanFrole 1]
]

let sorted-persons sort-by [ [householdIDP] of ?1 < [householdIDP] of ?2 ] persons with [sampledMarriedMan = 1]

ask persons with [sampledMarriedWoman = 1]
[

```

```

let match2 match-id2 sorted-persons householdIDP
set your-home match2
set malePartnerAge [AGEP] of match2
set malePartner [SEX] of match2
set malePartnerRace [RAC1P] of match2
set malePartnerHISP [HISP] of match2
set booleanMDrugProblem [booleanMDrugProblem] of match2
set Mesteem [Mesteem] of match2
set booleanMrole [booleanMrole] of match2 ]

let sorted-persons2 sort-by [ [householdIDP] of ?1 < [householdIDP] of ?2 ] persons with [sampledUnmarriedMan =
1]

ask persons with [sampledUnmarriedWoman = 1]
[
let match2 match-id2 sorted-persons2 householdIDP
set your-home match2
set malePartnerAge [AGEP] of match2
set malePartner [SEX] of match2
set malePartnerRace [RAC1P] of match2
set malePartnerHISP [HISP] of match2
set booleanMDrugProblem [booleanMDrugProblem] of match2
set Mesteem [Mesteem] of match2
set booleanMrole [booleanMrole] of match2 ]

ask persons [
if ((sampledUnmarriedWoman = 1) or (sampledMarriedWoman = 1))
[ set sampledFemaleHead 1]]

ask persons with [sampledFemaleHead = 1 and malePartner = 0]
[ set sampledFemaleHead 0]

ask persons with [(sampledMarriedMan = 1) or (sampledUnmarriedMan = 1)]
[ set sampledMaleHead 1 ]

set numberOfServices count welfare-places
ask welfare-places
[ set maxEducationTime 12 ]

ask shelters with [_id = 23]
[ set beds 1
set allbeds 1 ]

ask shelters with [_id = 27]
[ set beds 1
set allbeds 1 ]

ask shelters [if beds != 1 [die] ]
if Shelter-status = "original capacity"
[
ask shelters
[
set availableBeds beds
set totalBeds allbeds

```

```

]
]

if Shelter-status = "decreased capacity"
[
ask shelters
[
set availableBeds round (beds - beds * percent-of-shelter-capacity / 100)
set totalBeds round (allbeds - allbeds * percent-of-shelter-capacity / 100)
if availableBeds < 0 [set availableBeds 0]
if totalBeds < 0 [ set totalBeds 0]
]]

if Shelter-status = "increased capacity"
[
ask shelters
[
set availableBeds round (beds + beds * percent-of-shelter-capacity / 100)
set totalBeds round (allbeds + allbeds * percent-of-shelter-capacity / 100)
]]

ask persons with [sampledFemaleHead = 1]
[
if malePartner = 2 or malePartner = 4 [set booleanCohabiting 1]
set MFamilyContact numberFriends
set FFamilyContact numberFriends
set coupleFriends MFamilyContact + FFamilyContact
if (coupleFriends = 0)[ set numberSocialOutings 0]
if (coupleFriends > 0 and coupleFriends <= 5)[ set numberSocialOutings 1]
if (coupleFriends > 5 and coupleFriends <= 10)[ set numberSocialOutings 2]
if (coupleFriends > 10 and coupleFriends <= 15)[ set numberSocialOutings 3]
if (coupleFriends > 15) [ set numberSocialOutings 4 ]
if MVpersons = 1 [ set relationshipDuration 1 ]
if MVpersons = 2 [ set relationshipDuration vary 1 2 ]
if MVpersons = 3 [ set relationshipDuration vary 2 4 ]
if MVpersons = 4 [ set relationshipDuration vary 5 9 ]
if MVpersons = 5 [ set relationshipDuration vary 10 19 ]
if MVpersons = 6 [ set relationshipDuration vary 20 29 ]
if MVpersons = 7 [ set relationshipDuration vary 30 39 ]

set booleanPartner 1
set booleanMaleOffender 1
if (booleanMDrugProblem = 1 ) [set booleanOffenderUsedAlcohol 1]
if (booleanFDrugProblem = 1) [set booleanVictimUsedAlcohol 1]
if AGEp >= 30 [ set booleanVictim30Plus 1 ]
if AGEp <= 18 [ set booleanVictim18Minus 1 ]

set booleanHome 1
set personAge AGEp
set availableForJobSearch true
ifelse SCHL <= 17 [set booleanLowEducation 1] [set booleanLowEducation 0]
if ENG = 3 or ENG = 4 [ set booleanEnglishDif 1 ]
if ENG < 3 [set booleanEnglishDif 0]

set welfare-place-list-regular []
set welfare-place-list-regular sort-by [[distance myself] of ?1 < [distance myself] of ?2] welfare-places in-radius 11

```

```

set welfare-place-list1 [ ]

ask households [die]
ask persons with [RAC1P >= 3 and HISP = 1 and sampledMaleHead != 1] [die]
ask persons with [ AGEP < 15] [die]
ask persons-on patches with [ city-boundary != 1 ] [die]
ask households-on patches with [ city-boundary != 1 ] [die]
setup-coefficients
set month-count 0
set year-count 0
set week-count 0
set timeCount 0
set a 1
ask persons with [ sampledFemaleHead = 1 ]
[ set my-friends [ n-of numberFriends persons ] of self ]

ask patches [
  set poverty count persons-here with [POVPIP <= 100]

  set totPop count persons-here
  set numberBlack count persons-here with [ RAC1P = 2 and HISP = 1 ]
  set numberWhite count persons-here with [ RAC1P = 1 and HISP = 1 ]
  set numberHispanic count persons-here with [ RAC1P >= 1 and HISP >= 2 ]
  set totalSampledWomen count persons-here with [ sampledFemaleHead = 1 ] ]

let v 0
while [v <= 873] ; 873 is the number of census tracts in the area
[
  let _hispanics sum [numberHispanic] of patches with [chicago-tracts = v]
  let _whites sum [numberWhite] of patches with [chicago-tracts = v]
  let _blacks sum [numberBlack] of patches with [chicago-tracts = v]
  let _poor sum [poverty] of patches with [chicago-tracts = v]
  let values2 sum [totPop] of patches with [chicago-tracts = v]

  ask patches with [chicago-tracts = v] [
    if values2 > 0
    [
      set densityBlack _blacks / values2 * 100
      set densityWhite _whites / values2 * 100
      set densityHispanic _hispanics / values2 * 100
      set POVdensity _poor / values2 * 100
    ]
  ]
  set v v + 1
]

end

```

Setting up coefficients for the equations

to setup-coefficients

```

set constantPhysicalViolence -0.42
set constantVerbalViolence 0.6
set constantInjuryViolence 0.7

```

set constantSeekingHelp -2.2
set constantHelpVictims -0.41
set constantVictimCallingPolice -2.245
set constantThirdPartyCallingPolice -1.810
set constantLowIncomeEmplt -0.372

set services-weight-array array:from-list n-values 4 [0]
array:set services-weight-array 0 1.92
array:set services-weight-array 1 2.32
array:set services-weight-array 2 1.53
array:set services-weight-array 3 1.77

set coefficient-verbal-violence-array array:from-list n-values 17 [0]
array:set coefficient-verbal-violence-array 0 0.073
array:set coefficient-verbal-violence-array 1 -0.36
array:set coefficient-verbal-violence-array 2 -0.008
array:set coefficient-verbal-violence-array 3 -0.001
array:set coefficient-verbal-violence-array 4 0.1
array:set coefficient-verbal-violence-array 5 -0.09
array:set coefficient-verbal-violence-array 6 0.286
array:set coefficient-verbal-violence-array 7 -0.539
array:set coefficient-verbal-violence-array 8 -0.01
array:set coefficient-verbal-violence-array 9 0.012
array:set coefficient-verbal-violence-array 10 -0.012
array:set coefficient-verbal-violence-array 11 0.035
array:set coefficient-verbal-violence-array 12 -0.254
array:set coefficient-verbal-violence-array 13 0.689
array:set coefficient-verbal-violence-array 14 0.221
array:set coefficient-verbal-violence-array 15 -0.13
array:set coefficient-verbal-violence-array 16 -0.182

set coefficient-physical-violence-array array:from-list n-values 17 [0]
array:set coefficient-physical-violence-array 0 0.662
array:set coefficient-physical-violence-array 1 0.035
array:set coefficient-physical-violence-array 2 -0.037
array:set coefficient-physical-violence-array 3 -0.001
array:set coefficient-physical-violence-array 4 -0.007
array:set coefficient-physical-violence-array 5 -0.012
array:set coefficient-physical-violence-array 6 0.43
array:set coefficient-physical-violence-array 7 0.403
array:set coefficient-physical-violence-array 8 -0.067
array:set coefficient-physical-violence-array 9 -0.009
array:set coefficient-physical-violence-array 10 -0.001
array:set coefficient-physical-violence-array 11 0.033
array:set coefficient-physical-violence-array 12 0.063
array:set coefficient-physical-violence-array 13 1.147
array:set coefficient-physical-violence-array 14 0.931
array:set coefficient-physical-violence-array 15 -0.145
array:set coefficient-physical-violence-array 16 -0.306

set coefficient-injury-violence-array array:from-list n-values 17 [0]
array:set coefficient-injury-violence-array 0 0.166
array:set coefficient-injury-violence-array 1 -0.079
array:set coefficient-injury-violence-array 2 -0.165
array:set coefficient-injury-violence-array 3 0.009
array:set coefficient-injury-violence-array 4 0.473

array:set coefficient-injury-violence-array 5 -0.047
array:set coefficient-injury-violence-array 6 0.422
array:set coefficient-injury-violence-array 7 0.491
array:set coefficient-injury-violence-array 8 -0.051
array:set coefficient-injury-violence-array 9 0.039
array:set coefficient-injury-violence-array 10 -0.108
array:set coefficient-injury-violence-array 11 0.004
array:set coefficient-injury-violence-array 12 -0.339
array:set coefficient-injury-violence-array 13 1.91
array:set coefficient-injury-violence-array 14 1.47
array:set coefficient-injury-violence-array 15 -0.296
array:set coefficient-injury-violence-array 16 -0.403

set coefficient-leaving-abuser-array array:from-list n-values 13 [0]

array:set coefficient-leaving-abuser-array 0 -0.31
array:set coefficient-leaving-abuser-array 1 0.03
array:set coefficient-leaving-abuser-array 2 0.14
array:set coefficient-leaving-abuser-array 3 0.23
array:set coefficient-leaving-abuser-array 4 0.2
array:set coefficient-leaving-abuser-array 5 -0.01
array:set coefficient-leaving-abuser-array 6 0.1
array:set coefficient-leaving-abuser-array 7 -0.02
array:set coefficient-leaving-abuser-array 8 -0.19
array:set coefficient-leaving-abuser-array 9 1.75
array:set coefficient-leaving-abuser-array 10 -0.25
array:set coefficient-leaving-abuser-array 11 0.02
array:set coefficient-leaving-abuser-array 12 -0.01

set coefficient-helping-victims-array array:from-list n-values 7 [0]

array:set coefficient-helping-victims-array 0 0.17
array:set coefficient-helping-victims-array 1 -0.01
array:set coefficient-helping-victims-array 2 -0.01
array:set coefficient-helping-victims-array 3 0.12
array:set coefficient-helping-victims-array 4 0.3
array:set coefficient-helping-victims-array 5 0.35
array:set coefficient-helping-victims-array 6 0.12

set coefficient-victim-calling-police-array array:from-list n-values 41 [0]

array:set coefficient-victim-calling-police-array 0 -.329
array:set coefficient-victim-calling-police-array 1 -0.964
array:set coefficient-victim-calling-police-array 2 -1.595
array:set coefficient-victim-calling-police-array 3 -1.079
array:set coefficient-victim-calling-police-array 4 .361
array:set coefficient-victim-calling-police-array 5 1.196
array:set coefficient-victim-calling-police-array 6 .629
array:set coefficient-victim-calling-police-array 7 .225
array:set coefficient-victim-calling-police-array 8 .999
array:set coefficient-victim-calling-police-array 9 -.289
array:set coefficient-victim-calling-police-array 10 .456
array:set coefficient-victim-calling-police-array 11 .918
array:set coefficient-victim-calling-police-array 12 .819
array:set coefficient-victim-calling-police-array 13 -1.146
array:set coefficient-victim-calling-police-array 14 -.994
array:set coefficient-victim-calling-police-array 15 -.192
array:set coefficient-victim-calling-police-array 16 -.495

```

array:set coefficient-victim-calling-police-array 17 -.692
array:set coefficient-victim-calling-police-array 18 .293
array:set coefficient-victim-calling-police-array 19 -.04
array:set coefficient-victim-calling-police-array 20 -.065
array:set coefficient-victim-calling-police-array 21 .222
array:set coefficient-victim-calling-police-array 22 .116
array:set coefficient-victim-calling-police-array 23 -.105
array:set coefficient-victim-calling-police-array 24 .231
array:set coefficient-victim-calling-police-array 25 .629
array:set coefficient-victim-calling-police-array 26 1.153
array:set coefficient-victim-calling-police-array 27 .356
array:set coefficient-victim-calling-police-array 28 -.640
array:set coefficient-victim-calling-police-array 29 -0.941
array:set coefficient-victim-calling-police-array 30 .248
array:set coefficient-victim-calling-police-array 31 .013
array:set coefficient-victim-calling-police-array 32 .273
array:set coefficient-victim-calling-police-array 33 -.084
array:set coefficient-victim-calling-police-array 34 .154
array:set coefficient-victim-calling-police-array 35 -.038
array:set coefficient-victim-calling-police-array 36 -.165
array:set coefficient-victim-calling-police-array 37 .213
array:set coefficient-victim-calling-police-array 38 -.789
array:set coefficient-victim-calling-police-array 39 -.824
array:set coefficient-victim-calling-police-array 40 -.601

```

```

set coefficient-third-party-calling-police-array array:from-list n-values 41 [0]

```

```

array:set coefficient-third-party-calling-police-array 0 .04
array:set coefficient-third-party-calling-police-array 1 -1.481
array:set coefficient-third-party-calling-police-array 2 -1.202
array:set coefficient-third-party-calling-police-array 3 -.955
array:set coefficient-third-party-calling-police-array 4 -.05
array:set coefficient-third-party-calling-police-array 5 1.313
array:set coefficient-third-party-calling-police-array 6 .855
array:set coefficient-third-party-calling-police-array 7 -.180
array:set coefficient-third-party-calling-police-array 8 1.020
array:set coefficient-third-party-calling-police-array 9 .373
array:set coefficient-third-party-calling-police-array 10 .669
array:set coefficient-third-party-calling-police-array 11 .908
array:set coefficient-third-party-calling-police-array 12 .822
array:set coefficient-third-party-calling-police-array 13 -.387
array:set coefficient-third-party-calling-police-array 14 -.838
array:set coefficient-third-party-calling-police-array 15 -.168
array:set coefficient-third-party-calling-police-array 16 -.203
array:set coefficient-third-party-calling-police-array 17 -.717
array:set coefficient-third-party-calling-police-array 18 .189
array:set coefficient-third-party-calling-police-array 19 -.890
array:set coefficient-third-party-calling-police-array 20 -.215
array:set coefficient-third-party-calling-police-array 21 -.221
array:set coefficient-third-party-calling-police-array 22 -.116
array:set coefficient-third-party-calling-police-array 23 -.257
array:set coefficient-third-party-calling-police-array 24 .115
array:set coefficient-third-party-calling-police-array 25 .285
array:set coefficient-third-party-calling-police-array 26 -.891
array:set coefficient-third-party-calling-police-array 27 .144
array:set coefficient-third-party-calling-police-array 28 .311
array:set coefficient-third-party-calling-police-array 29 .173

```

```

array:set coefficient-third-party-calling-police-array 30 -.806
array:set coefficient-third-party-calling-police-array 31 -.117
array:set coefficient-third-party-calling-police-array 32 .070
array:set coefficient-third-party-calling-police-array 33 .032
array:set coefficient-third-party-calling-police-array 34 .151
array:set coefficient-third-party-calling-police-array 35 -.137
array:set coefficient-third-party-calling-police-array 36 -.135
array:set coefficient-third-party-calling-police-array 37 -.012
array:set coefficient-third-party-calling-police-array 38 .169
array:set coefficient-third-party-calling-police-array 39 .354
array:set coefficient-third-party-calling-police-array 40 -.569

```

```

set coefficient-array-low-income-mother-emplt array:from-list n-values 5 [0]
array:set coefficient-array-low-income-mother-emplt 0 -.0718
array:set coefficient-array-low-income-mother-emplt 1 -.0386
array:set coefficient-array-low-income-mother-emplt 2 -.0810
array:set coefficient-array-low-income-mother-emplt 3 -.0266
array:set coefficient-array-low-income-mother-emplt 4 -.0806

```

end

to setup-data-on-substance-abuse-problems

;; for females:

```

if (SEX = 2 and RAC1P = 1 and HISP = 1) [ ; for White Non-Hispanics
  if (AGEP >= 18 and AGEP <= 29 and rand? 0.0292 ) [set booleanFDrugProblem 1 ]
  if (AGEP >= 30 and AGEP <= 44 and rand? 0.0556 ) [set booleanFDrugProblem 1 ]
  if (AGEP >= 45 and AGEP <= 64 and rand? 0.0202 ) [set booleanFDrugProblem 1 ]
  if (AGEP >= 65 and rand? 0.0036 ) [ set booleanFDrugProblem 1 ]]

```

```

if ( SEX = 2 and RAC1P = 2 and HISP = 1) [ ; for Black Non-Hispanic
  if (AGEP >= 18 and AGEP <= 29 and rand? 0.021 ) [set booleanFDrugProblem 1 ]
  if (AGEP >= 30 and AGEP <= 44 and rand? 0.0151 ) [set booleanFDrugProblem 1 ]
  if (AGEP >= 45 and AGEP <= 64 and rand? 0.0125 ) [set booleanFDrugProblem 1 ]
  if (AGEP >= 65 and rand? 0.0012) [set booleanFDrugProblem 1 ]]

```

```

if (SEX = 2 and HISP >= 2) [ ; for All Hispanics
  if (AGEP >= 18 and AGEP <= 29 and rand? 0.0304 ) [set booleanFDrugProblem 1 ]
  if (AGEP >= 30 and AGEP <= 44 and rand? 0.0146 ) [set booleanFDrugProblem 1 ]
  if (AGEP >= 45 and AGEP <= 64 and rand? 0.0063 ) [set booleanFDrugProblem 1 ]
  if (AGEP >= 65 and rand? 0.0 ) [set booleanFDrugProblem 1 ]]

```

;; for males

```

if (SEX = 1 and RAC1P = 1 and HISP = 1) [
  if (AGEP >= 18 and AGEP <= 29 and rand? 0.1019 ) [set booleanMDrugProblem 1 ]
  if (AGEP >= 30 and AGEP <= 44 and rand? 0.101 ) [set booleanMDrugProblem 1 ]
  if (AGEP >= 45 and AGEP <= 64 and rand? 0.0597 ) [set booleanMDrugProblem 1 ]
  if (AGEP >= 65 and rand? 0.0238 ) [set booleanMDrugProblem 1 ]]

```

```

if (SEX = 1 and RAC1P = 2 and HISP = 1) [
  if (AGEP >= 18 and AGEP <= 29 and rand? 0.0692 ) [set booleanMDrugProblem 1 ]
  if (AGEP >= 30 and AGEP <= 44 and rand? 0.0704 ) [set booleanMDrugProblem 1 ]
  if (AGEP >= 45 and AGEP <= 64 and rand? 0.0448 ) [set booleanMDrugProblem 1 ]
  if (AGEP >= 65 and rand? 0.0179 ) [set booleanMDrugProblem 1 ]]

```

```

if (SEX = 1 and HISP >= 2) [
  if (AGEP >= 18 and AGEP <= 29 and rand? 0.09 ) [set booleanMDrugProblem 1 ]
  if (AGEP >= 30 and AGEP <= 44 and rand? 0.0488 ) [set booleanMDrugProblem 1 ]
  if (AGEP >= 45 and AGEP <= 64 and rand? 0.0435 ) [set booleanMDrugProblem 1 ]
  if (AGEP >= 65 and rand? 0.0369 ) [set booleanMDrugProblem 1 ]]

```

end

Main procedures:

```

extensions [ gis array ]

```

```

breed [ persons person ]
breed [ households household ]
breed [ shelters shelter ]
breed [ welfare-places welfare-place ]
breed [ police-stations police-station ]
patches-own [
  police-areas community-areas city-boundary chicago-tracts totPOP POVdensity density poverty poverty2
  totPop numberBlack numberWhite numberHispanic
  densityBlack densityWhite densityHispanic
  totalSampledWomen totalSurvivors violenceRate]

```

;; GO procedure that determines what functions are called
to go

```

set time-step 12
if time-step = 52 [ask shelters [ set maxShelterTime round (max_time / 4) ] ]
if time-step = 12 [ask shelters [ set maxShelterTime round (max_time / 30) ] ]
set timeCount timeCount + 1
if timeCount > time-step
[
  set timeCount 1
  set year-count year-count + 1
]

```

```

ask shelters [
  set #requests 0
  set #returnedbeds 0
  set #grantedservice 0]

```

```

ask persons with [sampledFemaleHead = 1]
[
  set victimCalledPolice? false
  set isHurtPhysically? false
  set isHurtInjuriously? false
  set visitedShelter? false
  set visitedServiceLocation? false
  set gotService? false
  set leftAbuser? false
  set talkedToFriend? false
  set helpedVictim? false
  if timeCount > time-step [ set receivedInformalSupport? false ]
  set lowIncomeMomFoundJob? false
]

```

;; determine probability of finding a job

ask persons with [sampledFemaleHead = 1 and availableForJobSearch = true and POVPIP <= 100 and PINCP < 16640 and lifetimeExposure = true]

```
[
  calculate-probability-low-income-mom-finding-job
  ifelse lowIncomeMomFoundJob? = true
  [
    set COW 1
    set PINCP 16640
    set householdIncome householdIncome + PINCP
    set availableForJobSearch false
  ]
  loop-through-centers
]
```

;;;; determines person's safety status (if in a shelter); sets homeless, shelter, education and child care counters

ask persons with [sampledFemaleHead = 1]

```
[
  if currentlyInShelter? = true
  [
    set isCurrentlySafe? true
    set shelterClock shelterClock + 1
    set in-need-for-home false
  ]

  if isHomeless? = true
  [
    set homelessClock homelessClock + 1
  ]

  if foundEducService? = true
  [
    set availableForJobSearch false
    set educationClock educationClock + 1 ]

  if foundChildCare? = true
  [ set childCareClock childCareClock + 1 ]
]
```

;;;; resets education clock and determines the status depending on whether the person found an educational service

ask persons with [sampledFemaleHead = 1 and foundEducService? = true]

```
[
  if educationClock >= time-step
  [
    set foundEducService? false
    set educationClock 0
    set availableForJobSearch true
    set SCHG 0
  ]
]
```

;;;;; the same as above for child care services

```
ask persons with [sampledFemaleHead = 1 and foundChildCare? = true]
[
  if childCareClock >= time-step
  [
    set foundChildCare? false
    set booleanChild 1
    set childCareClock 0
  ] ]
```

;;;;; determines whether it is time for persons to leave the shelter. If so, the shelter determines the number of available beds after the person left. The person determines whether she will become homeless or not on the basis of income.

```
ask persons with [currentlyInShelter? = true]
[
  if shelterClock >= [ maxShelterTime ] of myShelter
  [
    set currentlyInShelter? false
    set shelterClock 0
    ask in-link-neighbors
    [
      set availableBeds availableBeds + 1 ]
    ask my-in-links [die]

    if POVPIP <= 100 and PINCP < 16640
    [
      set isCurrentlySafe? false
      set isHomeless? true
      set in-need-for-home true
      set randHomelessTime random time-step
    ]

    if POVPIP <= 100 and PINCP >= 16640
    [
      set isCurrentlySafe? true
      set isHomeless? false
    ]

    if POVPIP > 100
    [
      set isCurrentlySafe? true
      set isHomeless? false
    ] ] ]
```

;;;;; determines the actions of homeless women – going to shelters again or going to community centers

```
ask persons with [isHomeless? = true]
[
  loop-through-centers

  ifelse foundHouseAid? = true
```

```

[
  set isCurrentlySafe? true
  set isHomeless? false
  set homelessClock 0
][

continue-shelters
]
]

;;; determines whether a person returns home after some period of homelessness

```

```

ask persons with [isHomeless? = true]
[
  if homelessClock >= randHomelessTime
  [
    set homelessClock 0
    set isHomeless? false
    set isCurrentlySafe? false
    move-to your-home
  ]
]
]

```

```

;; determines probability of violence in a couple for a given time step
ask persons with [sampledFemaleHead = 1]
[
  if isCurrentlySafe? = false
  [
    calculate-probability-violence
  ]

  if isHurtPhysically? = true or isHurtInjuriously? = true
  [
    set lifeTimeExposure true
  ]
]
]

```

;;;determines whether a person talks to her friends (assuming asking for help) and whether friends help her

```

ask persons with [lifeTimeExposure = true and isCurrentlySafe? = false]
[
  ifelse not any? my-friends
  [
    set levelOfSupport [0] of self ]
  [
    calculate-talking-to-friends
    ifelse talkedToFriend? = false
    [
      set levelOfSupport [0] of self
    ][
      let good-friend one-of my-friends
      ask good-friend
      [ calculate-probability-helping-victims ]

      ifelse [helpedVictim?] of good-friend = true

```

```

[
  set receivedInformalSupport? true
  determine-level-of-support ]
[
  set receivedInformalSupport? false
  set levelOfSupport 0
]
]
]
]

```

;;;;;;;;;determines whether a person calls police after the incident

```

ask persons with [ isHurtPhysically? = true or isHurtInjuriously? = true ]
[
  set victimCalledPolice? calculate-probability-victim-calling-police
]

```

;;;;;;;;; determines whether a person leaves the abuser, goes to a shelter and whether she becomes homeless as based on the income

```

ask persons with [ isCurrentlySafe? = false and lifeTimeExposure = true ]
[
  calculate-leaving-relationship
  if leftAbuser? = false
  [
    set isCurrentlySafe? false ]
]

```

```

ask persons with [leftAbuser? = true]
[
  continue-shelters
  if currentlyInShelter? = false
  [
    if POVPIP <= 100 and PINCP < 16640
    [
      set isHomeless? true
      set randHomelessTime random time-step
      set isCurrentlySafe? false
      set in-need-for-home true
    ]

    if POVPIP <= 100 and PINCP >= 16640
    [
      set isHomeless? false
      set isCurrentlySafe? true
    ]

    if POVPIP > 100
    [ set isHomeless? false
      set isCurrentlySafe? true ]
  ]
]

```


;; update graphs and stats

update-police-calls
update-monthly-counts
update-plots

tick

end

Functions:

; calculates probability of violence in a couple for a given time step

to calculate-probability-violence

set HHincomeTenths householdIncome / 1000
if householdIncome > 0 [set F%income PINCP / householdIncome * 10]
ifelse receivedInformalSupport? = true [set booleanCrisisSupport 1] [set booleanCrisisSupport 0]

set violence-variable-array array:from-list n-values 17 [0]
array:set violence-variable-array 0 booleanBlack
array:set violence-variable-array 1 booleanHispanic
array:set violence-variable-array 2 HHincomeTenths
array:set violence-variable-array 3 F%income
array:set violence-variable-array 4 booleanMrole
array:set violence-variable-array 5 booleanFrole
array:set violence-variable-array 6 booleanChildUnder5
array:set violence-variable-array 7 booleanCohabiting
array:set violence-variable-array 8 relationshipDuration
array:set violence-variable-array 9 MFamilyContact
array:set violence-variable-array 10 FFfamilyContact
array:set violence-variable-array 11 numberSocialOutings
array:set violence-variable-array 12 booleanCrisisSupport
array:set violence-variable-array 13 booleanFDrugProblem
array:set violence-variable-array 14 partnersDrugProblem
array:set violence-variable-array 15 Mesteem
array:set violence-variable-array 16 Festeem

let regressionVerbalViolence calculate-regression violence-variable-array coefficient-verbal-violence-array
constantVerbalViolence

let regressionPhysicalViolence calculate-regression violence-variable-array coefficient-physical-violence-array
constantPhysicalViolence

let regressionInjuryViolence calculate-regression violence-variable-array coefficient-injury-violence-array
constantInjuryViolence

let denominator-be (1 + exp(regressionVerbalViolence) + exp(regressionPhysicalViolence) +
exp(regressionInjuryViolence))

set probabilityOfVerbalViolence (exp(regressionVerbalViolence) / denominator-be)

let _probabilityOfPhysicalViolence (exp(regressionPhysicalViolence) / denominator-be) / time-step

let _probabilityOfInjuryViolence (exp(regressionInjuryViolence) / denominator-be) / time-step

```
set isHurtPhysically? boolean? _probabilityOfPhysicalViolence
set isHurtInjuriously? boolean? _probabilityOfInjuryViolence
```

```
end
```

```
:: calculates whether a person calls police after the incident
```

```
to-report calculate-probability-victim-calling-police
```

```
if (rand? 0.048) [set booleanGun 1]
if (rand? 0.12) [set booleanOtherWeapon 1]
if (isHurtPhysically? = true or isHurtInjuriously? = true) [set booleanPhysicalInjury 1]
if (monthlyCountActsPerPerson <= 4) [ set booleanOnetoFourPriorVictimization 1]
if (monthlyCountActsPerPerson >= 5) [ set booleanFivePlusPriorVictimization 1]
if PINCP >= 40000 [ set booleanHighIncome 1 ]
if PINCP <= 25000 [ set booleanLowIncome 1 ]
```

```
set calling-police-variable-array array:from-list n-values 41 [0]
array:set calling-police-variable-array 0 booleanSexOffense
array:set calling-police-variable-array 1 booleanPartner
array:set calling-police-variable-array 2 booleanOtherFamily
array:set calling-police-variable-array 3 booleanOtherKnown
array:set calling-police-variable-array 4 booleanMaleOffender
array:set calling-police-variable-array 5 booleanGun
array:set calling-police-variable-array 6 booleanOtherWeapon
array:set calling-police-variable-array 7 booleanUnknownWeapon
array:set calling-police-variable-array 8 booleanPhysicalInjury
array:set calling-police-variable-array 9 booleanUnknownInjury
array:set calling-police-variable-array 10 booleanOffenderUsedAlcohol
array:set calling-police-variable-array 11 booleanOffenderUsedDrugs
array:set calling-police-variable-array 12 booleanUnknownAlcoholDrugUseOffender
array:set calling-police-variable-array 13 booleanVictimUsedAlcohol
array:set calling-police-variable-array 14 booleanVictimUsedDrugs
array:set calling-police-variable-array 15 booleanUnknownAlcoholDrugUseVictim
array:set calling-police-variable-array 16 booleanVictimPrecipitation
array:set calling-police-variable-array 17 booleanUnknownVictimPrecipitation
array:set calling-police-variable-array 18 booleanHome
array:set calling-police-variable-array 19 booleanUnknownLocation
array:set calling-police-variable-array 20 booleanOnetoFourPriorVictimization
array:set calling-police-variable-array 21 booleanFivePlusPriorVictimization
array:set calling-police-variable-array 22 booleanUnknownNumberPriorVictimization
array:set calling-police-variable-array 23 boolean1970s
array:set calling-police-variable-array 24 boolean1980s
array:set calling-police-variable-array 25 boolean1990s
array:set calling-police-variable-array 26 booleanUnknownDecade
array:set calling-police-variable-array 27 booleanVictim30Plus
array:set calling-police-variable-array 28 booleanVictim18Minus
array:set calling-police-variable-array 29 booleanVictimAgeUnknown
array:set calling-police-variable-array 30 booleanMen
array:set calling-police-variable-array 31 booleanEducation
array:set calling-police-variable-array 32 booleanBlack
array:set calling-police-variable-array 33 booleanHispanic
array:set calling-police-variable-array 34 booleanOtherUnknownRace
array:set calling-police-variable-array 35 booleanHighIncome
array:set calling-police-variable-array 36 booleanLowIncome
```

```

array:set calling-police-variable-array 37 booleanUnknownIncome
array:set calling-police-variable-array 38 booleanMaleVictimXPartner
array:set calling-police-variable-array 39 booleanMaleVictimXMaleOffender
array:set calling-police-variable-array 40 booleanSexualAssaultXOtherKnown

let regressionVictimCalling calculate-regression calling-police-variable-array coefficient-victim-calling-police-
array constantVictimCallingPolice
let regressionThirdPartyCalling calculate-regression calling-police-variable-array coefficient-third-party-calling-
police-array constantThirdPartyCallingPolice

let denominator2-be (1 + exp(regressionVictimCalling) + exp(regressionThirdPartyCalling))

set probabilityVictimCalledPolice exp(regressionVictimCalling) / denominator2-be

let _victimCalledPolice? boolean? probabilityVictimCalledPolice
report _victimCalledPolice?

end

;; calculates the probability a low-income person (with a poverty threshold of <= 100) finds a job

to calculate-probability-low-income-mom-finding-job

ifelse SCHL <= 17 [set booleanLowEducation 1] [set booleanLowEducation 0]
if ENG = 3 or ENG = 4 [ set booleanEnglishDif 1 ]
if ENG < 3 [set booleanEnglishDif 0]
if (lifeTimeExposure = true)
[
  ifelse monthlyCountActsPerPerson >= 1
  [
    set booleanHealthProblem 1 ]
  [
    set booleanHealthProblem 0
  ]
]

set variable-array-low-income-mother-emplt array:from-list n-values 5 [0]
array:set variable-array-low-income-mother-emplt 0 booleanLowEducation
array:set variable-array-low-income-mother-emplt 1 booleanEnglishDif
array:set variable-array-low-income-mother-emplt 2 booleanNoCar
array:set variable-array-low-income-mother-emplt 3 booleanChild
array:set variable-array-low-income-mother-emplt 4 booleanHealthProblem

set resultOfCalculation calculate-regression variable-array-low-income-mother-emplt coefficient-array-low-
income-mother-emplt constantLowIncomeEmplt
set probabilityLowIncomeMomFoundJob exp(resultOfCalculation) / (1 + exp(resultOfCalculation)) / time-step

set lowIncomeMomFoundJob? boolean? probabilityLowIncomeMomFoundJob

end

```

:: calculates probability that a person leaves the relationship

to calculate-leaving-relationship

```
let randValue random-float 1

ifelse randValue < 0.24
[
  set rangeSeverityIncident 3 ]
[
  ifelse randValue >= 0.24 and randValue < 0.47
  [ set rangeSeverityIncident 4 ]
  [ ifelse randValue >= 0.47 and randValue < 0.7
  [ set rangeSeverityIncident 2]
  [ ifelse randValue >= 0.7 and randValue < 0.84
  [ set rangeSeverityIncident 5]
  [ ifelse randValue >= 0.84 and randValue < 0.96
  [ set rangeSeverityIncident 6]
  [ set rangeSeverityIncident 1 ]
  ]
]
]
]

if SCHL = 1 [set educationRange 1]
if SCHL >= 2 and SCHL <= 9 [set educationRange 2]
if SCHL >= 10 and SCHL <= 15 [set educationRange 3]
if SCHL = 16 or SCHL = 17 [set educationRange 4]
if SCHL = 18 or SCHL = 19 [set educationRange 5]
if SCHL = 20 [set educationRange 6]
if SCHL = 21 [set educationRange 7]
if SCHG = 16 [set educationRange 8]
if SCHL >= 22 [set educationRange 9]

if (PINCP <= 5000) [set range 1]
if (PINCP > 5001 and PINCP <= 10000) [set range 2]
if (PINCP > 10001 and PINCP <= 20000) [set range 3]
if (PINCP > 20001 and PINCP <= 30000) [set range 4]
if (PINCP > 30001 and PINCP <= 40000) [set range 5]
if (PINCP > 40001 and PINCP <= 50000) [set range 6]
if (PINCP > 50001 and PINCP <= 60000) [set range 7]
if (PINCP > 60001 and PINCP <= 70000) [set range 8]
if (PINCP > 70001) [ set range 9 ]

set mostSevereIncident rangeSeverityIncident

ifelse randValue < 0.215
[ set harassmentLevel 0 ]
[ ifelse randValue >= 0.215 and randValue < 0.342
[ set harassmentLevel 1 ]
[ ifelse randValue >= 0.342 and randValue < 0.435
[ set harassmentLevel 2]
[ ifelse randValue >= 0.435 and randValue < 0.522
[set harassmentLevel 3]
```

```

[ ifelse randValue >= 0.522 and randValue < 0.586
  [ set harassmentLevel 4 ]
  [ ifelse randValue >= 0.586 and randValue < 0.670
    [ set harassmentLevel 5]
    [ ifelse randValue >= 0.670 and randValue < 0.913
      [ set harassmentLevel vary 6 10 ]
      [ set harassmentLevel vary 11 19]
    ]
  ]
]
]
]
]
]

```

```

ifelse randValue < 0.251
[ set powerControlLevel 5]
[ ifelse randValue >= 0.251 and randValue < 0.419
  [ set powerControlLevel 0]
  [ ifelse randValue >= 0.419 and randValue < 0.586
    [ set powerControlLevel 4]
    [ ifelse randValue >= 0.586 and randValue < 0.737
      [ set powerControlLevel 3]
      [ ifelse randValue >= 0.737 and randValue < 0.882
        [ set powerControlLevel 1]
        [set powerControlLevel 2]
      ]
    ]
  ]
]
]
]
]

```

```

ifelse randValue < 0.355
[ set healthLevel 3]
[ ifelse randValue >= 0.355 and randValue < 0.653
  [set healthLevel 2]
  [ ifelse randValue >= 0.653 and randValue < 0.811
    [set healthLevel 4]
    [ ifelse randValue >= 0.811 and randValue < 0.924
      [set healthLevel 5]
      [ set healthLevel 1]
    ]
  ]
]
]
]

```

```

if booleanHispanic = 1
[
  ifelse randValue < 0.245
  [ set lackOfDepression 0]
  [ ifelse randValue >= 0.245 and randValue < 0.434
    [ set lackOfDepression 3]
    [ ifelse randValue >= 0.434 and randValue < 0.598
      [ set lackOfDepression 2]
      [ ifelse randValue >= 0.598 and randValue < 0.755
        [ set lackOfDepression 5]
        [ ifelse randValue >= 0.755 and randValue < 0.887

```

```

        [ set lackOfDepression 4]
        [ set lackOfDepression 1]
    ]
]
]
]
]

if booleanHispanic = 0
[
    ifelse randValue < 0.426
    [ set lackOfDepression 0]
    [ ifelse randValue >= 0.426 and randValue < 0.639
    [ set lackOfDepression 1]
    [ ifelse randValue >= 0.639 and randValue < 0.762
    [ set lackOfDepression 3]
    [ ifelse randValue >= 0.762 and randValue < 0.881
    [ set lackOfDepression 2]
    [ ifelse randValue >= 0.881 and randValue < 0.964
    [ set lackOfDepression 4]
    [ set lackOfDepression 5]
    ]
    ]
    ]
    ]
]

if (timeCount = (time-step - 1) and monthlyCountActsPerPerson > 0) [ set logIncidentsYear (log
monthlyCountActsPerPerson 10)]

set educationLevel educationRange
set personalIncome2 range
if COW >= 1 and COW <= 7 [ set booleanEmployedPTorFT 1 ]
if COW = 8 [ set booleanHomemaker 1 ]
if SCHG >= 15 [ set booleanStudent 1 ]
set supportNetwork levelOfSupport

set leaving-abuser-variable-array array:from-list n-values 13 [0]
array:set leaving-abuser-variable-array 0 logIncidentsYear
array:set leaving-abuser-variable-array 1 mostSevereIncident
array:set leaving-abuser-variable-array 2 harassmentLevel
array:set leaving-abuser-variable-array 3 powerControlLevel
array:set leaving-abuser-variable-array 4 healthLevel
array:set leaving-abuser-variable-array 5 lackOfdepression
array:set leaving-abuser-variable-array 6 educationLevel
array:set leaving-abuser-variable-array 7 personalIncome2
array:set leaving-abuser-variable-array 8 booleanEmployedPTorFT
array:set leaving-abuser-variable-array 9 booleanHomemaker
array:set leaving-abuser-variable-array 10 booleanStudent
array:set leaving-abuser-variable-array 11 supportNetwork
array:set leaving-abuser-variable-array 12 severityBysupport

set resultOfCalculation calculate-regression leaving-abuser-variable-array coefficient-leaving-abuser-array
constantSeekingHelp
set probabilityPersonLeftAbuser (exp(resultOfCalculation) / (1 + exp(resultOfCalculation))) / time-step

```

```

set leftAbuser? boolean? probabilityPersonLeftAbuser

end

```

:: calculates probability whether a person is willing to talk to her friends

to calculate-talking-to-friends

```

if booleanBlack = 1
[
  ifelse rand? 0.44
  [ set talkedToFriend? true ]
  [ set talkedToFriend? false ] ]

if booleanHispanic = 1
[
  ifelse rand? (vary 0.74 0.78)
  [ set talkedToFriend? true ]
  [ set talkedToFriend? false ] ]

if booleanBlack = 0 and booleanHispanic = 0
[
  ifelse rand? 0.92
  [ set talkedToFriend? true ]
  [ set talkedToFriend? false ] ]

end

```

:: calculates how much support people are willing to provide to the survivor

to determine-level-of-support

```

let _support 0

if (booleanBlack = 1) [ set _support (random-normal 3.5 0.83) / 7 ]
if (booleanHispanic = 1) [ set _support (random-normal 3.2 0.8) / 7 ]
if (booleanHispanic = 0 and booleanBlack = 0) [set _support 8.55 / 12 ]

ifelse change-public-awareness? = true
[
  let _tempSupport _support * 12
  let _zsupport 12 - _tempSupport
  set levelOfSupport ( _tempSupport + _zsupport * change-public-awareness / 100)
] [ set levelOfSupport _support * 12 ]

end

```

:: calculates probability that friends are willing to help violence survivors

to calculate-probability-helping-victims

```

if (SEX = 2) [ set booleanFemale 1 ]
if (SEX = 2) [ set helperAgeFemale AGEF ]
if (SEX = 1) [ set helperAgeMale AGEF ]

```

```

let _tempbelief 0
let _tempprev 0
let _anothertempbelief 0
let _anothertemprate 0

if (booleanHispanic = 0) [set _tempbelief random-normal 4.26 0.69]

if (booleanHispanic = 1) [set _tempbelief 2.3 / 4 * 5]

if (booleanHispanic = 0) [set _tempprev random-normal 2.93 1.07 ]

if (booleanHispanic = 1 and SEX = 2) [ set _tempprev 3.2 / 4 * 5 ]

if (booleanHispanic = 1 and SEX = 1) [ set _tempprev 2.3 / 4 * 5 ]

ifelse change-public-awareness? = false
[
  set beliefHelpingVictimsIPV _tempbelief
  set perceivedPrevalenceRatesIPV _tempprev
]
[
  set _anothertempbelief (5 - _tempbelief)
  set beliefHelpingVictimsIPV (_tempbelief + _anothertempbelief * change-public-awareness / 100)

  set _anothertemprate (5 - _tempprev)
  set perceivedPrevalenceRatesIPV (_tempprev + _anothertemprate * change-public-awareness / 100)
]

set personalExposureIPV monthlyCountActsPerPerson]

set helping-victims-variable-array array:from-list n-values 7 [0]
array:set helping-victims-variable-array 0 booleanFemale
array:set helping-victims-variable-array 1 helperAgeFemale
array:set helping-victims-variable-array 2 helperAgeMale
array:set helping-victims-variable-array 3 beliefHelpingVictimsIPV
array:set helping-victims-variable-array 4 childhoodExposureIPV
array:set helping-victims-variable-array 5 personalExposureIPV
array:set helping-victims-variable-array 6 perceivedPrevalenceRatesIPV

set resultOfCalculation calculate-regression helping-victims-variable-array coefficient-helping-victims-array
constantHelpVictims
set probabilityPersonHelped exp(resultOfCalculation) / (1 + exp(resultOfCalculation))

ifelse (rand? probabilityPersonHelped)
[ set helpedVictim? true ]
[ set helpedVictim? false ]

end
;; calculates probability that a person will go to a shelter and that she will receive a bed based on how many beds
are available

to continue-shelters

if currentlyInShelter? = false
[

```



```

let q 0

set shelterList []
set shelterList [self] of shelters
set shelterList sort-by [[distance myself] of ?1 < [distance myself] of ?2] shelters

foreach shelterList
[
  set myShelter ?

  let cultural_sensitivity 0
  let final_decision 0

  if ([[densityBlack] of patch-here] of myShelter <= 10) and ([[densityHispanic] of patch-here] of myShelter <= 10)
  [
    if whiteNonHispanic = 1
    [ set cultural_sensitivity 1 ]

    if booleanHispanic = 1
    [ set cultural_sensitivity cultural-sensitivity / 100 ]

    if booleanBlack = 1
    [ set cultural_sensitivity cultural-sensitivity / 100 ]

  ]

  if [[densityBlack] of patch-here] of myShelter > 50
  [
    if whiteNonHispanic = 1
    [ set cultural_sensitivity cultural-sensitivity / 100 ]

    if booleanHispanic = 1
    [ set cultural_sensitivity cultural-sensitivity / 100 ]

    if booleanBlack = 1
    [ set cultural_sensitivity 1 ]

  ]

  if ([[densityBlack] of patch-here] of myShelter > 10 and [[densityBlack] of patch-here] of myShelter <= 50)
  [
    if whiteNonHispanic = 1
    [ set cultural_sensitivity 1 ]

    if booleanHispanic = 1
    [ set cultural_sensitivity 1 ]

    if booleanBlack = 1
    [ set cultural_sensitivity 1 ] ]

  if ([[densityHispanic] of patch-here] of myShelter > 10 and [[densityBlack] of patch-here] of myShelter < 10)
  [
    if whiteNonHispanic = 1
    [ set cultural_sensitivity cultural-sensitivity / 100 ]

    if booleanHispanic = 1

```

```

[ set cultural_sensitivity 1 ]

if booleanBlack = 1
[ set cultural_sensitivity cultural-sensitivity / 100 ]
]

let _myDistance [distance myself] of myShelter

let _myDistanceConverted _myDistance * factor * 0.001

set probVisitShelter (0.525 * exp(-0.11 * _myDistanceConverted))

set final_decision probVisitShelter * cultural_sensitivity

set visitedShelter? boolean? final_decision ;probVisitShelter

move-to myShelter

if visitedShelter? = true
[
  calculate-#refs

  ask myShelter [ create-link-to myself ]

  ask links [hide-link]
  ask myShelter
  [
    if availableBeds >= 0 and availableBeds <= totalBeds
    [
      if (count out-link-neighbors <= availableBeds)
      [
        ask out-link-neighbors
        [
          set gotService? true
          set currentlyInShelter? true
          set isHomeless? false
        ]
      ]
    ]

    if (count out-link-neighbors > availableBeds)
    [
      let requesters out-link-neighbors
      let lucky availableBeds
      ask n-of lucky requesters
      [
        set gotService? true
        set currentlyInShelter? true
        set isHomeless? false
      ]
    ]
  ]

  if [gotService?] of myself = true [ set availableBeds availableBeds - 1]
  ask [out-link-neighbors] of self
  [
    if visitedShelter? = true and gotService? = false
    [

```

```

        ask my-in-links [die]
      ]
    ]
  ]
  ifelse gotService? = true [ stop ] [ set currentlyInShelter? false ]
]
]
end

```

:: calculates number of people who requested beds from a given shelter

to calculate-#refs

```

ask myShelter
[set #requests #requests + 1]
end

```

:: calculates probability that a person will visit a community service center

to loop-through-centers

```

let search-distance 0
let max_distance 0

if any? welfare-places
[
  ifelse empty? welfare-place-list-regular
  [
    set welfare-place-list1a []
    set search-distance 3000 / factor
    set welfare-place-list-regular sort-by [[distance myself] of ?1 < [distance myself] of ?2] welfare-places in-
radius search-distance

    if empty? welfare-place-list-regular
    [
      set max_distance min [distance myself] of welfare-places
      set search-distance max_distance
      set welfare-place-list-regular sort-by [[distance myself] of ?1 < [distance myself] of ?2] welfare-places in-
radius search-distance
    ]
  ][
    set welfare-place-list1a array:from-list welfare-place-list-regular
    let _thedistance 0
    let _trr 0
    let _grr 0
    foreach n-values (array:length welfare-place-list1a) [?]
    [
      set _thedistance [distance myself] of array:item welfare-place-list1a ?
      set new-distance1 _thedistance * factor * 0.001
      ask array:item welfare-place-list1a ?
    ]
  ]
]

```

```

[
  let _atrx calculate-attract-access
  let _p [new-distance1] of myself
  set attractiveness-calculation _atrx * _p ^ -1
]

set _trr [attractiveness-calculation] of array:item welfare-place-list1a ?
set _grr _grr + _trr
]

set _temp-list []
set _temp-list array:to-list welfare-place-list1a

let b&b 0

set welfare-place-selected one-of _temp-list

set b&b [_trr] of welfare-place-selected
let _probHuff b&b / _grr

let _visitedServiceLocation? boolean? _probHuff

ifelse _visitedServiceLocation? = false
[
  set foundChildCare? false
  set foundEducService? false-value
  set foundFinAid? false
  set foundHouseAid? false
  set foundOtherAid? false
]
move-to welfare-place-selected
check-service-in-center
set welfare-place-list-regular remove welfare-place-selected welfare-place-list-regular
set welfare-place-list1a array:from-list welfare-place-list-regular
set _temp-list array:to-list welfare-place-list1a
]
]
end

```

;; determines the availability of services in a center depending on a woman's needs (education, childcare, housing or financial services)

```

to check-service-in-center

if booleanEnglishDif = 1
[
  ifelse [ESL] of welfare-place-selected = 1
  [
    set foundEducService? true
    set ENG 1
    set in-need-for-education false
    set SCHG 16
  ]
]

```

```

    set foundEducService? False ] ]
if (SCHL <= 17)
[
  ifelse [GED] of welfare-place-selected = 1
  [
    set foundEducService? true
    set in-need-for-education false
    set SCHG 16
    set SCHL 18
  ]
  [ set foundEducService? false ]
]

if (booleanChild = 1)
[
  ifelse [children_service] of welfare-place-selected = 1
  [
    set foundChildCare? true
    set booleanChild 0
    set in-need-for-childcare false ]
  [
    set foundChildCare? false
  ]
]

if (in-need-for-money = true)
[
  ifelse [emergency_service] of welfare-place-selected = 1
  [
    set foundFinAid? true
    set in-need-for-money false ]
  [
    set foundFinAid? false
  ]
]

if in-need-for-home = true
[
  ifelse [housing_assist] of welfare-place-selected = 1
  [
    set foundHouseAid? true
    set in-need-for-home false
  ]
  [
    set foundHouseAid? false
  ]
]

end

```

;; a method used to calculate attractiveness of a specific service center relative to other centers as based on the distance and available services

to-report calculate-attract-access

```

  set housing housing_assist
  if (GED = 1) or (ESL = 1) [set education 1]

```

```

set childcare children_service
set fin_needs emergency_service

set services-variable-array array:from-list n-values 4 [0]
array:set services-variable-array 0 housing
array:set services-variable-array 1 education
array:set services-variable-array 2 childcare
array:set services-variable-array 3 fin_needs

let result 0
foreach n-values (array:length services-variable-array) [?]
[
  let _rrrr ((array:item services-variable-array ?) * (array:item services-weight-array ?))
  set result result + _rrrr ]
report result

```

end

; a generic method used to calculate regressions

```

to-report calculate-regression [variableArray coefficientArray constant]
  let result constant
  foreach n-values (array:length variableArray) [?] [
    set result result + ( (array:item variableArray ?) * (array:item coefficientArray ?) )
  ]
  report result
end

```

; a generic method used to calculate a random integer in given range, inclusive

```

to-report vary [#low #high]
  report #low + random(#high - #low + 1)
end

```

; a generic method used to report probability and false or true, accordingly

```

to-report rand? [%prob]
  report %prob > random-float 1
end

```

; another generic method used to report probability and false or true, accordingly

```

to-report boolean? [#result]
  ifelse #result > random-float 1
  [report true]
  [report false]
end

```

*;; a generic method used to find a match between a person record and a household record as based on the ACS;
assigns all necessary information from the household to a given person*

```

to-report match-id [the-list i ]
  let lo 0
  let hi (length the-list)

```

```

while [ true ]
[
  let try int (( lo + hi ) / 2 )
  let tmp item try the-list
  if [ householdIDHH ] of tmp = i
  [ report tmp ]
  ifelse [ householdIDHH ] of tmp < i
  [ set lo try ]
  [ set hi try ]
  if lo = i
  [
    set tmp item lo the-list
    ifelse [householdIDHH] of tmp = i
    [ report tmp ]
    [ report -1 ] ; This means "fail"
  ]
]
]
end

```

;; same as above – the method is used to find and match couples for a given household and to assign all necessary information to a female

```

to-report match-id2 [the-list2 i2 ]
  let lo 0
  let hi (length the-list2)

  while [ true ]
  [
    let try int (( lo + hi ) / 2 )
    let tmp item try the-list2
    if [ householdIDP ] of tmp = i2
    [ report tmp ]
    ifelse [ householdIDP ] of tmp < i2
    [ set lo try ]
    [ set hi try ]
    if lo = i2
    [
      set tmp item lo the-list2
      ifelse [householdIDP] of tmp = i2
      [ report tmp ]
      [ report -1 ] ; This means "fail"
    ]
  ]
]
End

```

;; methods used to report false and true values

```

to-report true-value
  report true
end

```

```

to-report false-value

```

```
    report false
end
```

:: a method that updates number of police calls

to update-police-calls

```
ask persons with [sampledFemaleHead = 1 ]
[
  ifelse timeCount < time-step
  [
    if victimCalledPolice? = true
    [
      set monthlyPoliceCalls monthlyPoliceCalls + 1 ]
    ]
  [ set monthlyPoliceCalls 0 ]
]
end
```

:: a method that calculates total violent acts per person during the lifetime and during the year; police stations take statistics for their area of service as well

to update-monthly-counts

```
ask persons with [sampledFemaleHead = 1 ]
[
  ifelse (timeCount < time-step)
  [
    if (isHurtPhysically? = true)
    [
      set monthlyCountActsPerPerson monthlyCountActsPerPerson + 1
      set totalVictims 1
      ask police-stations with [district = [#PoliceDistrict] of myself ]
      [ set policeRecords policeRecords + 1
      ]
    ]
  ]

  if (isHurtInjuriouly? = true)
  [
    set monthlyCountActsPerPerson monthlyCountActsPerPerson + 1
    set totalVictims 1
    ask police-stations with [district = [#PoliceDistrict] of myself ]
    [ set policeRecords policeRecords + 1
    ]]

  if (isHurtPhysically? = true)
  [
    set monthlyPhysicalInjuries monthlyPhysicalInjuries + 1 ]

  if (isHurtInjuriouly? = true)
  [
    set monthlyInjurioulyInjuries monthlyInjurioulyInjuries + 1 ]
  ]
]
```



```

]]
set monthlyCountActsPerPerson 0
set monthlyPhysicalInjuries 0
set monthlyInjuriousInjuries 0
set totalVictims 0
    ask police-stations with [district = [#PoliceDistrict] of myself ]
    [ set policeRecords 0
    ]

if (isHurtPhysically? = true)
[
    set totalViolenceActs totalViolenceActs + 1 ]

    if (isHurtInjuriously? = true)
    [
        set totalViolenceActs totalViolenceActs + 1 ]
    ]

end

;; Example how to read csv file and create an object (similar files creating households, persons and community
centers are not included):

to read-shelters-file
file-close-all
file-open "other-data/chicago_shelters.csv"
let lineString file-read-line
while [ not file-at-end? ] [
    set lineString file-read-line
    create-shelters 1 [

        ;; read easting
        let commaIndex (position "," lineString)
        let ss substring lineString 0 commaIndex
        let easting read-from-string ss
        set xcor (easting - eastingOrigin) / factor
        set lineString substring lineString (commaIndex + 1) length lineString

        ;; read northing
        set commaIndex (position "," lineString)
        set ss substring lineString 0 commaIndex
        let northing read-from-string ss
        set ycor (northing - northingOrigin) / factor
        set lineString substring lineString (commaIndex + 1) length lineString

        ;; read ID
        set commaIndex (position "," lineString)
        set ss substring lineString 0 commaIndex
        let value read-from-string ss
        set _ID value
        set lineString substring lineString (commaIndex + 1) length lineString
    ]
]

```

```

;; read type_code
set commaIndex (position "," lineString)
set ss substring lineString 0 commaIndex
set value read-from-string ss
set type_code value
set lineString substring lineString (commaIndex + 1) length lineString

;; read beds
set commaIndex (position "," lineString)
set ss substring lineString 0 commaIndex
set value read-from-string ss
set beds value
set lineString substring lineString (commaIndex + 1) length lineString

;; read max_time
set commaIndex (position "," lineString)
set ss substring lineString 0 commaIndex
set value read-from-string ss
set max_time value
set lineString substring lineString (commaIndex + 1) length lineString

;; read any_serv
set value read-from-string lineString
set any_serv value

set shape "house colonial"
set color yellow
set size 8
]

]
file-close

end

```